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MEASUREMENT OF NEUTRAL TEMPERATURE IN THE 120-180 KM REGION OF THE ATMOSPHERE FOLLOWING TMA RELEASES FROM A ROCKET

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May 1979

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Atmospheric temperature measurements at approximately 160 km altitude over White Sands Missile Range on 24 September 1977 were made by the AlO sunlit resonance fluorescence technique. A rocket borne payload released trimethyl aluminum (TMA) in one large cloud at morning twilight. Twelve minutes of data were used to calculate temperatures at the top of the cloud averaging 628°K and at bottom averaging 578°K. The standard deviation of any one mea- → over

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20. ABSTRACT

surement involving typically 40 seconds of data was generally between 5 and 11°K. Included in this report is the most detailed description to date of the procedures and statistical background underlying the 'AℓQ Temperature' technique developed by the author over the last eleven years.

ACKNOWLEDGEMENT

We take pleasure in acknowledging the encouragement and assistance of Dr. Dan Golomb from 1967 onward in the development of the overall technique of measuring upper atmosphere temperatures using AlO.

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1.0 INTRODUCTION

Over the last 17 years many uses of TMA (trimethyl aluminum) trails in the upper atmosphere have been made by various experimenters (Blamont et al, 1961; Armstrong, 1963; Rosenberg et al, 1964). In addition to measuring winds and diffusion rates, (Authier et al, 1962, 1963, 1964; Authier, 1964; Harang, 1964; Golomb et al, 1967, 1972; Fees et al, 1974) have also measured temperature by studying the temperature dependent vibrational-rotational intensity distribution of the blue-green system of AlO ($B^2\Sigma^+ - X^2\Sigma^+$) generated when TMA is exposed to sunlight in the presence of atomic oxygen (see Figure 1).

Recent experiments under the direction of AFGL (Aladdin, Aeolus, etc.) have centered around rocket released puffs of TMA on the downleg of a rocket trajectory from 180 km down to 120 km with approximately 10 km spacing (see Figure 2).

A program involving one rocket payload for winds and temperature studies was conducted at White Sands Missile Range on 24 September, 1977. In this case the rocket made only one release at approximately 160 km altitude at 5:00 A.M. local time during morning twilight (8° solar depression). The experimental procedure consisted of observing the top and bottom of the cloud for 30 to 40 second periods. In general, adequate signal to noise ratio is maintained until 1 or 2° solar depression although, after this length of time (approximately 20 minutes) from an initial release at say 8° solar depression, only at the lowest altitudes 120-130 km are there "sharp" enough features to permit altitude discrimination in the spectrometer's line of sight and accurate photographic triangulation of altitude. In this program, only 12 minutes of data was taken with the above limitation being reached more quickly at the higher altitudes available in this particular experiment.

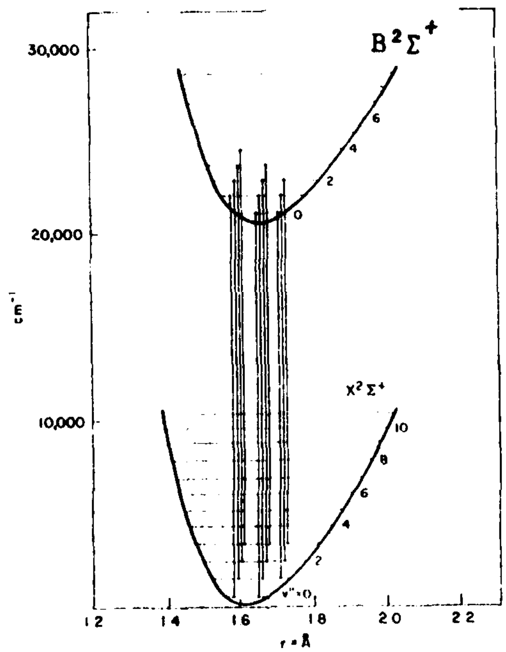


Figure 1. The $B^2\Sigma^+$ and $X^2\Sigma^+$ Levels of the AlO Molecule.

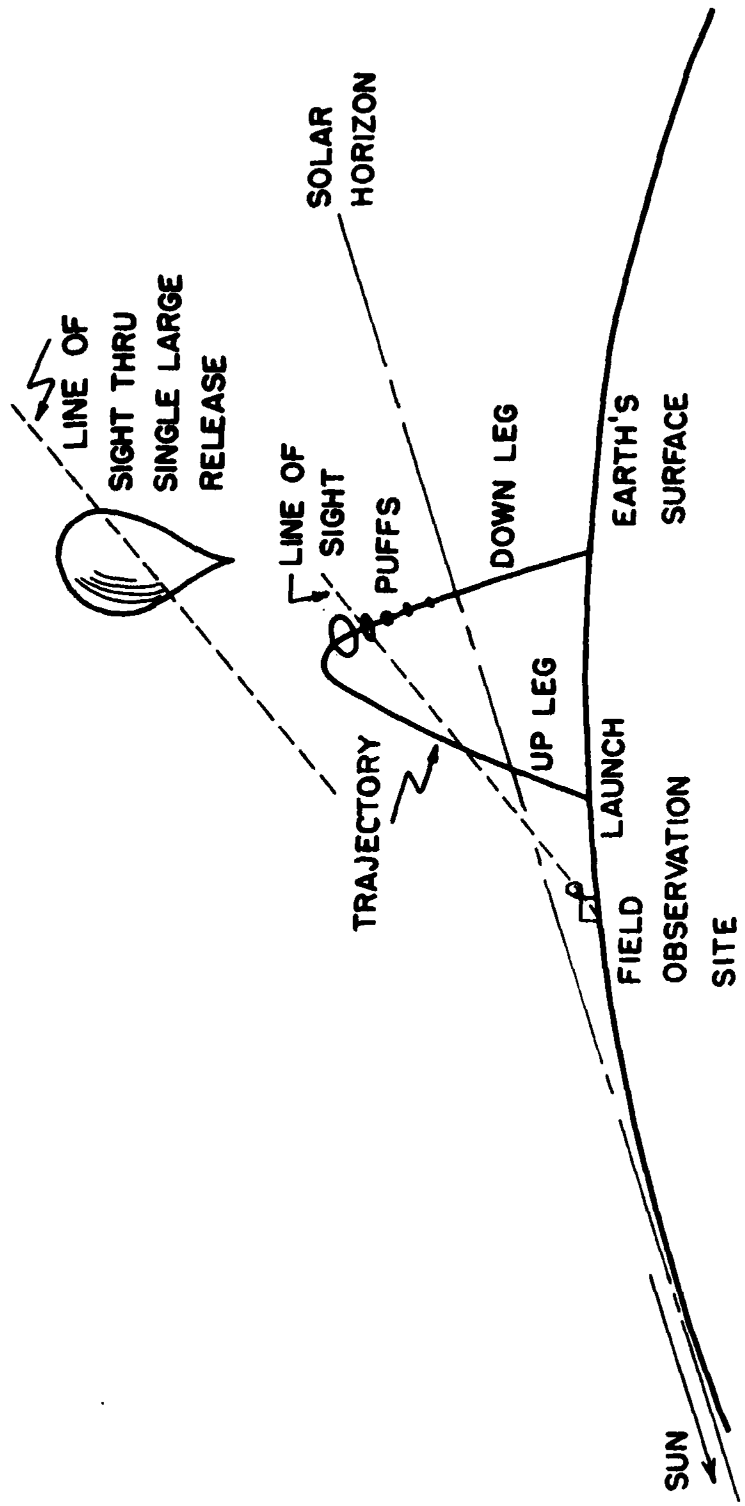


Figure 2. Observational Geometry

2.0 INSTRUMENTATION AND PROCEDURE

The heart of field instrumentation is a 1/2 meter Fastie-Ebert scanning spectrometer. The input optics is a 50 cm focal length F/5.0 lens which "images" the input slit upon the sky as a horizontal slit 7° wide by .06° high. The spectrometer is co-mounted on a tripod adjustable in elevation and azimuth along with a secondary electron conduction (SEC) vidicon low light level television camera (and a 35 mm photographic camera as backup) for both boresight recording and real-time aiming of the spectrometer. The grating of the spectrometer is tilted to scan in wavelength by a synchronous motor through an adjustable cam mechanism at a rate of one scan every five seconds. Photoelectron pulses from the photomultiplier are processed with standard "nuclear" counting electronics and recorded on a high speed (60 ips) magnetic tape recorder. Also recorded are a sample of the 60 Hz waveform driving the synchronous motor scanning the spectrometer and audio comments of the person aiming the spectrometer. A block diagram of the Field Instrumentation is shown in Figure 3.

The boresight TV camera is recorded on a video tape recorder along with time from a digital clock superimposed on one corner of the video frame. Also recorded on the video tape recorder's audio channel is the commentary of the "aimer" describing what he is pointing the instrument at as well as when he is moving it or holding steady on some feature (see Figure 4).

The aimer makes use of a TV monitor for aiming in addition to various direct sights mounted on the tripod. He also has view of a chart recorder displaying the spectrum being recorded in order to ascertain the quality (amplitude) of the spectra from a particular feature.

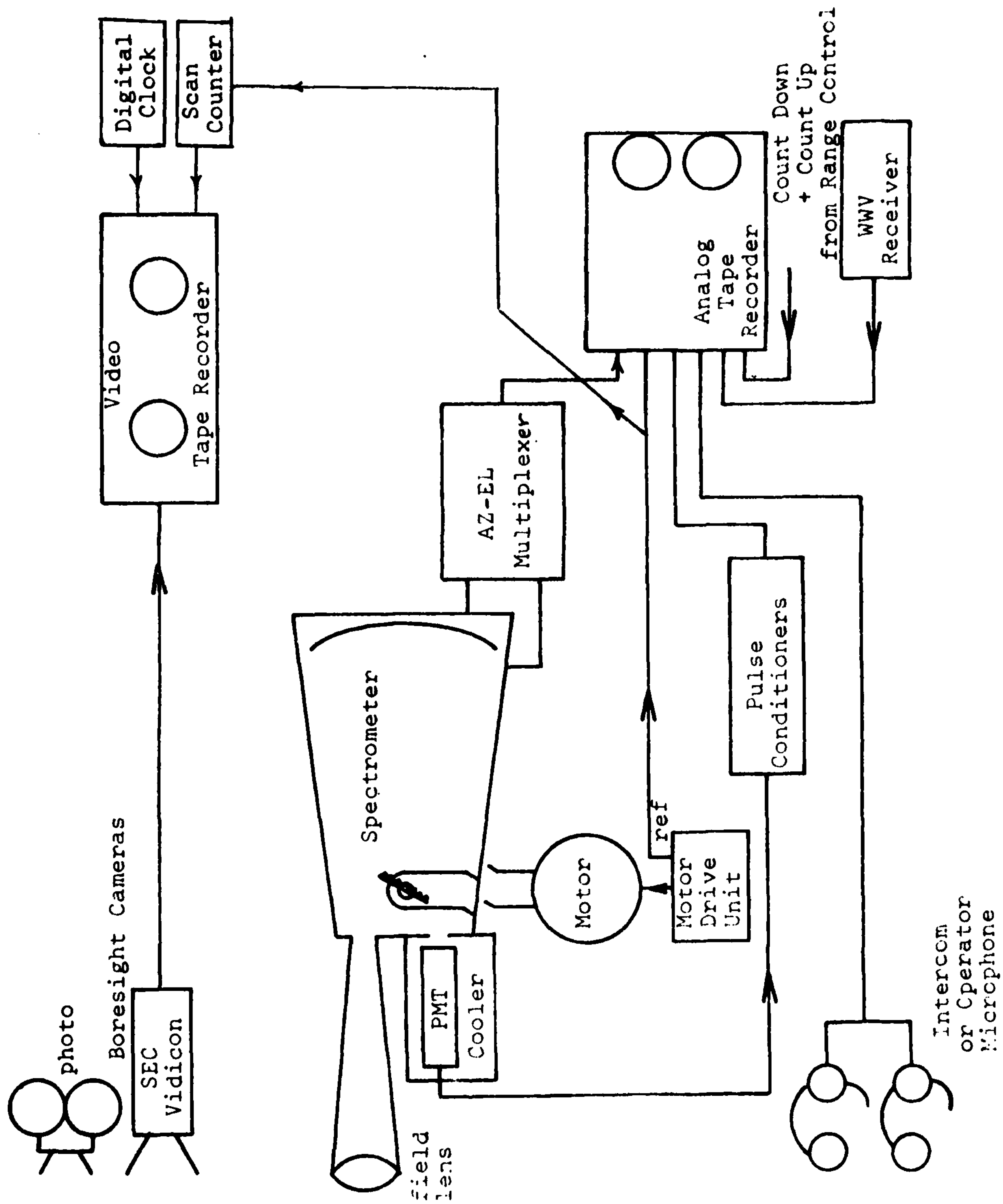


Figure 3. Block Diagram of Field Instrumentation

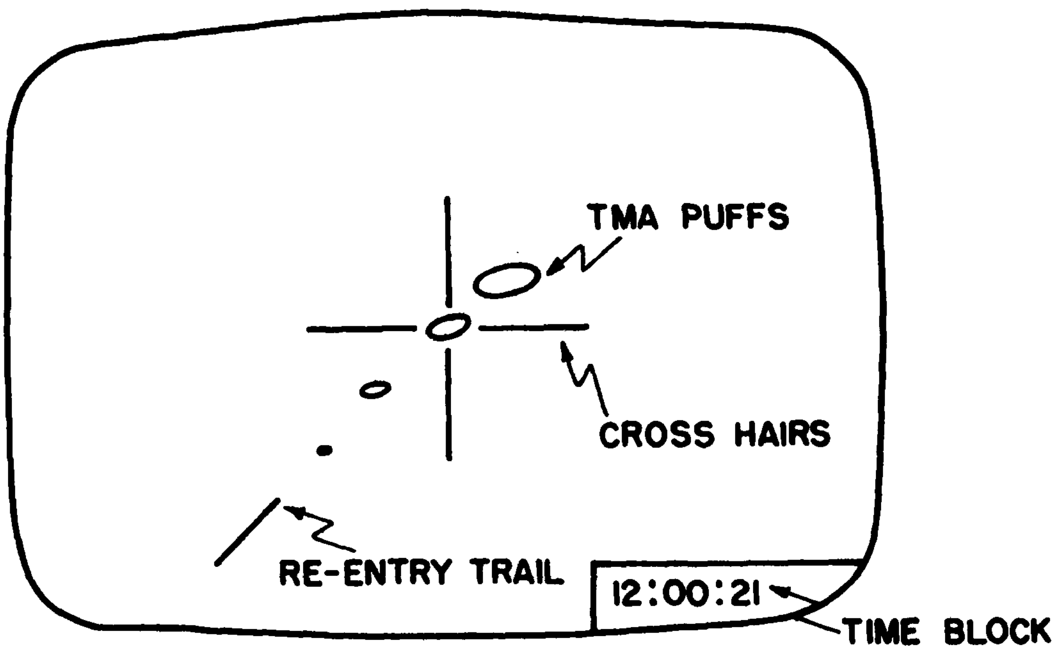


Figure 4. Boresight TV Monitor (Typical)

After the experiment certain calibrations are recorded. An iron-neon hollow cathode lamp is scanned to establish the wavelength calibration of the spectrometer and the shape of the spectrometer's slit function. A light box (LDF #6) with a radiance calibration traceable to an NBS quartz-iodine irradiance standard is scanned to establish the variation of the spectrophotometer's sensitivity with wavelength. Records of the photomultiplier output, with the spectrometer scan stopped, versus the step number of the calibrated apertures in the lightbox are used to establish the amplitude linearity of the counting-recording system. In a photon counting scheme such as this, counts are lost at higher counting rates due to "dead-time". Prior to the experiment boresight calibrations using a several kilometer distant light source are made to align all the sights as well as markers on the boresight TV monitor and fiduciaries on the photographic camera with the very narrow (vertically) field of view of the spectrometer. Later, during data reduction, playback of the TV recording of this boresight calibration will again allow us to place markers on the TV monitor used for playback.

3.0 DATA REDUCTION

Data reduction was carried out in the following steps. A block diagram of data reduction is shown in Figure 5.

1. Digitize Data - The tapes brought back from the field are "replayed" and the photon counts are totaled every 1/60th of a second using as a clock the recorded 60 Hz waveform originally driving the synchronous motor on the grating drive. The totalized counts are recorded on a digital tape recorder whose operation as well as the counting and interface to the analog "playback" tape recorder is handled by a microprocessor based system.

The following programs are used on the AFGL CDC 6600 computer:

2. Program CONVERS - The "stranger" type digital tape created above is converted to a SCOPE format file by CONVERS.

3. Program ALO TAPE DUMP - Prints all of the data on the high speed printer in an easy to examine format together with a running index to keep track of position along the tape (see Table 1).

4. Program LB AVG takes sections of data, that have been identified by examining the dump above as observations of the lightbox at various aperture steps, and computes the average count corresponding to the lightbox steps 0, 1, 2, 4, 8, 16, ..., 1024 (see Table 2).

5. Program LBTAU takes the averages computed above (k') plus the measured "hole factors" for each attenautor step on the light box (k) and adjusts the parameters α, β, τ in the expression below for best fit to properly weighted values of k and k'.

$$k' = \frac{\alpha k + \beta}{1 + (\alpha k + \beta) \tau}$$

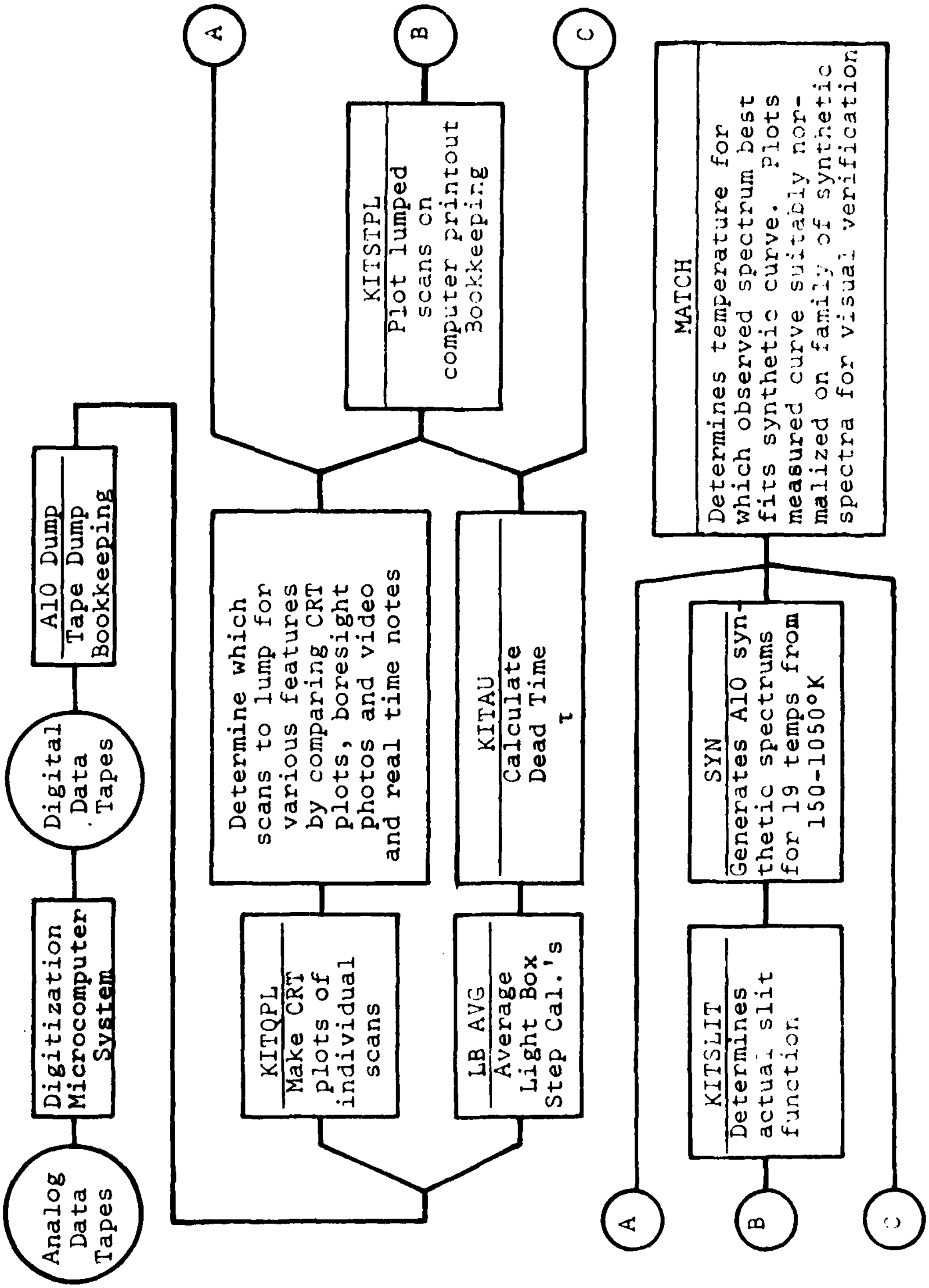


Figure 5. Block Diagram of Data Reduction

TABLE 1. SAMPLE OUTPUT OF A10 DUMP

FIRST WD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	LAST WD
10501	32	26	19	24	21	20	21	15	18	11	17	14	15	16	16	15	11	16	16	12	14	16	19	14	17	20	19	22	21	27	10530
10531	19	23	29	28	26	24	26	29	29	30	32	36	35	32	30	34	31	38	34	35	38	38	43	34	35	44	36	34	39	34	10560
10561	39	40	38	35	36	39	39	45	41	51	58	56	70	72	83	92	98	102	102	93	97	92	81	78	67	49	35	35	24	19	10590
10591	9	[illegible]	2	1	2	1	2	1	2	1	1	1	1	2	4	0	1	1	1	1	1	0	1	1	1	1	1	2	0	2	10620
10621	1	2	2	1	1	1	1	1	0	2	0	1	1	1	1	0	1	0	0	1	1	0	1	1	0	1	0	1	0	2	10650
10651	39	92	33	36	43	20	16	25	19	13	9	6	6	6	1	4	1	2	1	2	1	0	1	1	3	2	1	3	2	2	10680
10681	1	3	2	2	2	1	2	2	2	1	2	3	2	2	2	3	3	2	2	2	2	2	3	3	2	3	3	2	3	3	10710
10711	5	2	4	3	3	4	4	4	4	2	4	3	4	5	4	6	4	5	5	5	6	5	3	5	6	3	7	5	5	5	10740
10741	5	4	[illegible]	[illegible]	7	5	5	4	6	[illegible]	9	6	6	6	6	5	8	9	10	8	9	8	7	9	10	10	7	10	6	12	10770
10771	[illegible]	12	12	8	14	10	14	11	11	11	11	14	12	11	12	16	14	14	17	17	16	18	24	26	28	30	30	30	29	29	10800
10801	32	27	23	23	23	20	17	15	16	11	17	15	14	15	14	13	15	16	11	13	13	17	17	18	18	19	22	16	22	24	10830
10831	27	22	26	28	23	25	27	31	35	30	35	28	34	33	34	37	29	36	35	34	35	41	35	34	33	34	37	38	39	43	10860
10861	38	41	34	40	42	41	39	51	43	47	62	71	76	80	84	95	99	100	101	100	95	96	88	76	62	52	42	32	27	15	10890
10891	13	4	2	2	1	0	0	0	2	1	1	0	1	1	2	1	0	1	1	1	2	2	1	0	1	0	1	1	0	2	10920
10921	2	0	1	1	2	1	1	0	1	2	0	0	1	1	2	2	0	1	1	0	2	1	1	0	1	0	2	1	1	1	10950
10951	52	89	35	39	41	16	14	30	20	13	11	5	5	6	5	3	1	1	2	0	3	2	0	2	2	1	1	2	1	1	10980
10981	2	1	1	2	1	1	2	3	2	2	2	1	3	2	1	4	2	1	3	2	2	2	1	4	2	2	3	5	2	3	11010
11011	3	3	3	3	4	2	4	5	4	2	4	4	6	6	6	5	7	7	4	7	7	4	6	4	6	5	4	6	4	6	11040
11041	8	4	5	7	4	6	5	6	6	8	6	10	8	8	9	6	10	9	8	9	8	9	7	8	10	11	8	14	9	11	11070
11071	9	14	16	10	9	17	14	11	14	11	13	12	10	14	15	14	17	15	19	17	16	22	25	23	26	29	28	30	29	30	11100
11101	31	30	28	21	26	26	18	17	19	15	13	14	14	15	16	12	16	16	12	18	18	16	19	23	22	17	26	17	19	23	11130
11131	20	25	27	26	27	24	33	25	28	26	36	31	32	33	35	34	35	35	39	35	38	42	39	37	39	38	40	40	34	31	11160
11161	42	37	38	35	41	39	43	43	50	61	58	67	76	82	83	88	91	107	103	108	112	101	85	76	62	59	42	40	31	18	11190
11191	10	5	2	1	1	1	0	2	1	2	1	1	1	2	0	1	0	2	0	1	3	1	1	1	1	1	1	1	1	1	11220
11221	1	2	0	2	[illegible]	1	1	1	1	0	0	1	0	2	0	1	0	1	1	1	0	1	0	1	2	1	0	1	0	2	11250
11251	133	38	41	36	21	17	30	16	13	10	8	4	5	3	3	3	1	1	2	2	1	2	2	3	1	2	1	2	2	2	11280
11281	3	2	2	1	3	2	2	2	2	3	2	1	2	3	2	3	3	3	2	4	2	3	4	3	2	2	5	2	3	3	11310
11311	2	3	4	3	5	5	5	3	5	5	5	5	5	7	5	4	4	5	6	6	6	6	6	6	5	5	7	5	7	6	11340
11341	6	6	5	7	5	7	5	6	5	6	8	5	7	8	8	8	9	8	8	9	10	8	6	11	13	11	10	12	10	10	11370
11371	11	9	13	14	13	11	15	9	11	14	13	14	12	15	15	12	12	17	20	23	29	21	26	24	29	28	29	30	28	28	11400
11401	30	26	26	24	24	19	21	14	10	15	17	14	15	16	13	14	16	16	17	17	23	22	24	17	22	22	21	22	21	27	11430
11431	25	26	29	26	27	24	27	31	35	28	37	37	35	29	40	33	41	33	35	36	40	38	46	41	34	42	44	40	40	39	11460
11461	36	46	42	42	42	47	45	42	54	59	70	75	90	85	95	104	111	118	100	102	85	89	73	71	55	43	34	28	23	12	11490
11491	6	2	0	2	1	0	2	0	1	1	1	2	1	2	2	0	2	1	1	0	2	0	2	1	1	0	2	1	1	0	11520
11521	1	1	1	1	1	1	1	1	0	2	1	1	1	0	1	0	1	0	1	1	0	2	1	1	0	0	1	1	1	50	11550
11551	93	37	35	34	18	13	32	18	11	9	9	[illegible]	4	6	4	3	1	2	3	1	3	2	4	1	2	1	1	2	2	2	11580
11581	4	0	0	3	2	2	1	3	2	2	1	3	3	3	2	1	3	1	4	3	2	3	2	4	4	3	3	3	4	3	11610
11611	3	4	3	4	4	5	3	4	6	9	6	3	6	7	8	5	7	8	6	4	3	4	4	6	5	5	4	5	6	5	11640
11641	4	7	5	6	5	6	6	6	9	6	6	8	4	8	7	8	8	10	7	9	9	12	8	7	10	11	11	11	11	15	11670
11671	12	10	17	13	9	11	12	13	12	8	11	14	13	12	15	12	14	12	20	22	19	23	29	28	29	31	33	32	29	25	11700
11701	29	29	26	25	20	17	19	18	15	16	11	13	17	12	17	17	16	14	18	18	18	15	21	19	18	22	26	25	25	23	11730
11731	28	27	26	32	28	31	31	31	31	36	32	39	37	35	35	38	40	30	44	37	43	44	42	46	38	36	42	46	41	40	11760
11761	38	39	38	43	41	46	42	48	52	64	74	71	87	88	93	103	101	109	108	96	92	79	75	66	50	44	41	30	20	10	11790
11791	4	2	4	1	1	0	1	0	1	1	0	1	2	2	1	2	1	0	2	0	3	0	2	0	0	1	0	1	2	0	11820
11821	0	1	2	1	1	1	1	1	1	0	1	0	1	2	1	1	1	1	3	1	2	1	2	0	2	1	1	2	1	72	11850
11851	125	55	47	48	20	14	29	17	10	8	5	3	3	2	1	1	0	1	1	0	1	1	0	1	0	1	0	1	0	0	11880
11881	0	1	0	0	0	0	1	1	0	0	0	0	1	0	0	1	0	0	1	1	0	1	0	0	1	0	0	0	0	0	11910
11911	2	0	1	0	1	0	1	1	0	0	1	0	0	0	1	3	1	1	1	0	1	0	0	1	1	1	0	1	2	0	11940
11941	0	0	1	1	2	1	0	1	0	1	1	0	0	0	0	0	0	1	0	0	1	0	1	0	1	0	0	4	0	1	11970
11971	1	2	0	1	3	0	1	0	2	1	0	0	1	0	2	1	0	1	0	1	0	1	0	1	0	0	1	1	0	0	12000
FIRST WD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	LAST WD

FILE 2

TABLE 2.

LIGHT BOX AVERAGE (LBAVG) OUTPUT

		WORD		WORD		COUNT		APERTURE STEP
FILE	1	START	12878	END	137[illegible]	AVERAGE	251.[illegible]	1024
~~FILE~~	~~1~~	~~START~~	~~1[illegible]743~~	~~END~~	~~14466~~	~~AVERAGE~~	118.[illegible]	512
FILE	1	START	14475	END	151[illegible]	AVERAGE	63.[illegible]	256
FILE	1	START	151[illegible]	END	15[illegible]4	AVERAGE	23.[illegible]	128
FILE	1	START	15935	END	16[illegible]	AVERAGE	12.[illegible]	64
FILE	1	START	16655	END	17[illegible]	AVERAGE	5.[illegible]	32
FILE	1	START	17409	END	18[illegible]7	AVERAGE	3.[illegible]	16
~~FILE~~	~~1~~	~~START~~	~~18[illegible]~~	~~END~~	~~18[illegible]~~	~~AVERAGE~~	1.4	8
FILE	1	START	18859	END	19465	AVERAGE	.[illegible]	4
FILE	1	START	19539	END	2[illegible]	AVERAGE	.4	2
FILE	1	START	20275	END	2077[illegible]	AVERAGE	.[illegible]	1
FILE	1	START	21060	END	21541	AVERAGE	.1	0
FILE	1	START	21740	END	225[illegible]	AVERAGE	29.6	1024
~~FILE~~	~~1~~	~~START~~	~~22546~~	~~END~~	~~2318[illegible]~~	~~AVERAGE~~	11.[illegible]	512
FILE	1	START	23130	END	23[illegible]	AVERAGE	6.[illegible]	256
FILE	1	START	23935	END	2457[illegible]	AVERAGE	2.[illegible]	128
FILE	1	START	24600	END	25[illegible]	AVERAGE	1.[illegible]	64
FILE	1	START	25325	END	262[illegible]	AVERAGE	.6	32
FILE	1	START	26310	END	27[illegible]	AVERAGE	171.[illegible]	1024
~~FILE~~	~~1~~	~~START~~	~~27128~~	~~END~~	~~27[illegible]~~	~~AVERAGE~~	56.[illegible]	512
FILE	1	START	2784[illegible]	END	[illegible]57	AVERAGE	22.[illegible]	256
FILE	1	START	28566	END	29[illegible]	AVERAGE	10.1	128
FILE	1	START	2[illegible]	END	29[illegible]	AVERAGE	5.[illegible]	64
FILE	1	START	29970	END	30668	AVERAGE	2.[illegible]	32
FILE	1	START	3[illegible]720	END	31[illegible]	AVERAGE	1.[illegible]	16
~~FILE~~	~~1~~	~~START~~	~~31446~~	~~END~~	~~321[illegible]~~	~~AVERAGE~~	.6	8
FILE	1	START	32160	END	327[illegible]	AVERAGE	.[illegible]	4
FILE	1	START	32850	END	334[illegible]	AVERAGE	.1	2
FILE	1	START	3357[illegible]	END	341[illegible]	AVERAGE	.1	1
FILE	1	START	34320	END	3465[illegible]	AVERAGE	.[illegible]	0
FILE	1	START	3432[illegible]	END	346[illegible]	AVERAGE	.[illegible]	

where k' = measured counts

k = output of lightbox

τ = dead time

α = constant of proportionality since the hole factors for the aperture steps of the lightbox are in arbitrary units, not counts

β = an additive constant representing the dark current of the photomultiplier.

From this point forward in the data reduction the data can be corrected to remove the non-linearity introduced by the dead time inherent in the counting by the expression

$$k'' = \frac{k'}{1 - k'\tau} - \frac{\beta}{\alpha}$$

where k'' is the corrected counts (see Figure 6).

6. Program KITQPL makes plots on the CRT plotter of the raw data once the starting points of the scans are established from examining the dump of data in ALO TAPE DUMP. These "quick plots" can be visually correlated with the video tape boresight record by comparing the relative amplitude of the quick plot with the apparent brightness of the ALO image in the field of view. Once this timing has been established, a table is created of sequential scan numbers on the data tape versus the identification numbers on the video boresight record (see Figure 7).

7. Program KITSTPL makes strip plots on computer printout of the data tapes. Groups of sequential scans of the same feature in the TMA release are summed. Summed scans of the lightbox are plotted this way to establish the variation of sensitivity with wavelength of the instrument using the known calibration curves of the lightbox (traceable to NBS). This slight variation of sensitivity

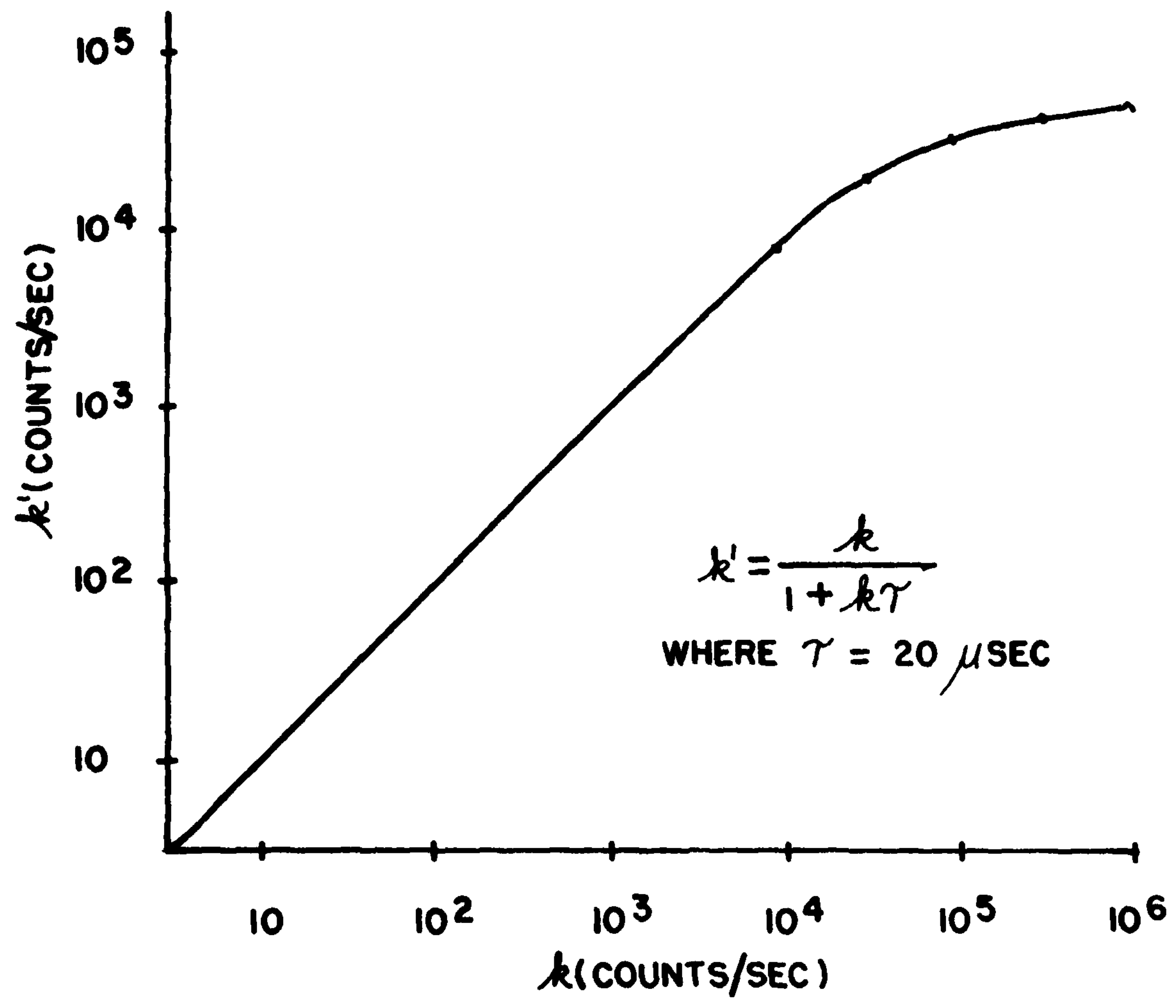


Figure 6. Dead Time Curves

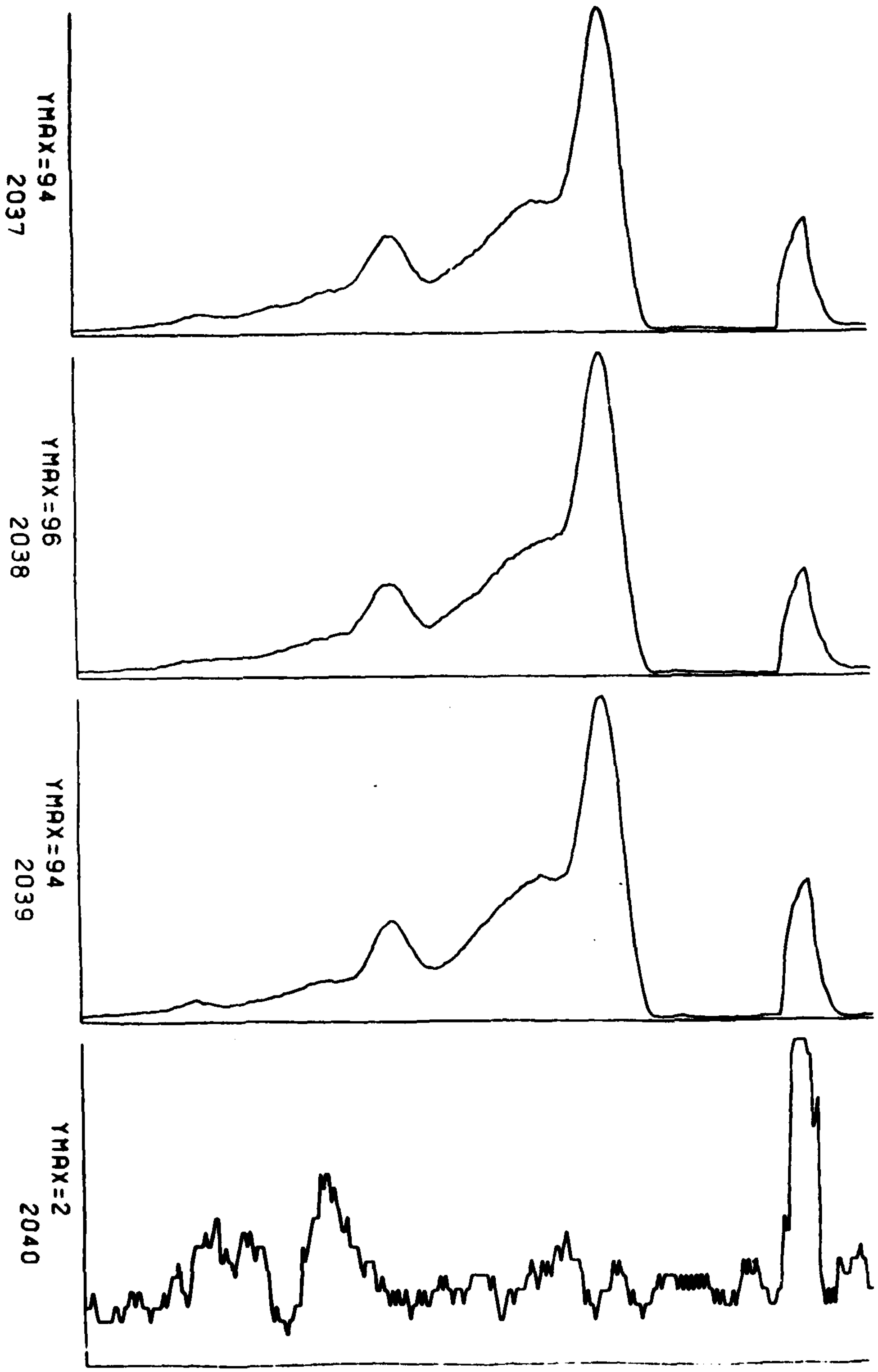


Figure 7. Quick Plot Sample (QPL)

(~5% over 100 Å) is used later to correct the data in MATCH (see Figure 8).

Scans of the iron hollow cathode lamp lines establish the wavelength calibration of the spectrometer system as well as the actual shape of the slit function.

8. Program KITSLIT takes the summed scans across selected lines and fits a triangular slit function to them, adjusting an arbitrary multiplicative constant, a background pedestal, the horizontal position and the width. Then scans of different lines can all be normalized and plotted on computer printout as shown in Figure 9. An accurate slit function can be deduced from this composite by hand drawing smoothed sections at the top and bottom of the straight line of the triangular function (physically, the sharp corners of the geometric optically correct triangular slit function are rounded off by diffraction).

9. Program SYN calculates a synthetic AlO spectra. The technique is similar to Harang (1966). The molecular parameters of Tyte and Nicholls (1964) are used to calculate the position of the rotational-vibrational lines. Populations of various rotational and vibrational levels are derived from the Boltzmann distribution law assuming thermal equilibrium with the ambient air which would appear to be a valid assumption up to approximately 170 km where the collision rate is 10/sec; the f-value of the AlO electronic transition is generally assumed to be 0.1 to 1.0 (Harang, 1966) implying that each molecule has 1 to 10 seconds or 10 to 100 collisions to attain thermal equilibrium between excitations. The solar excitation used is taken from the Utrecht Atlas (Minnaert et al, 1940). The band strength with Franck Condon factors is used to calculate absorption for various vibrational levels.

2 180 32

91	8.250
92	8.750
93	7.875
94	8.750
95	9.125
96	8.500
97	9.125
98	8.625
99	8.875
100	9.625
101	8.750
102	8.125
103	10.13
104	9.000
105	10.25
106	9.125
107	9.500
108	9.875
109	8.750
110	11.13
111	11.63
112	11.38
113	12.13
114	13.63
115	14.13
116	15.25
117	17.38
118	16.75
119	20.75
120	21.00
121	21.63
122	22.25
123	22.88
124	23.50
125	22.75
126	22.13
127	21.00
128	19.38
129	18.25
130	16.25
131	15.63
132	13.50
133	13.13
134	12.13
135	12.00
136	11.38
137	11.13
138	11.63
139	11.88
140	10.38
141	11.88
142	11.00
143	11.88

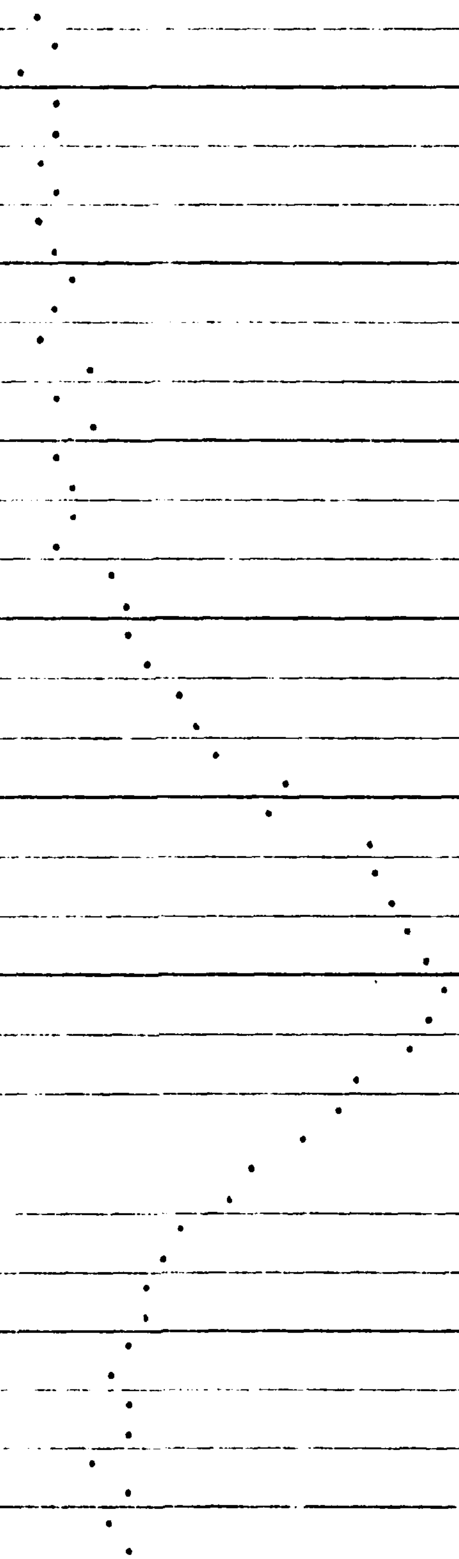


Figure 8. Sample of STPL Output

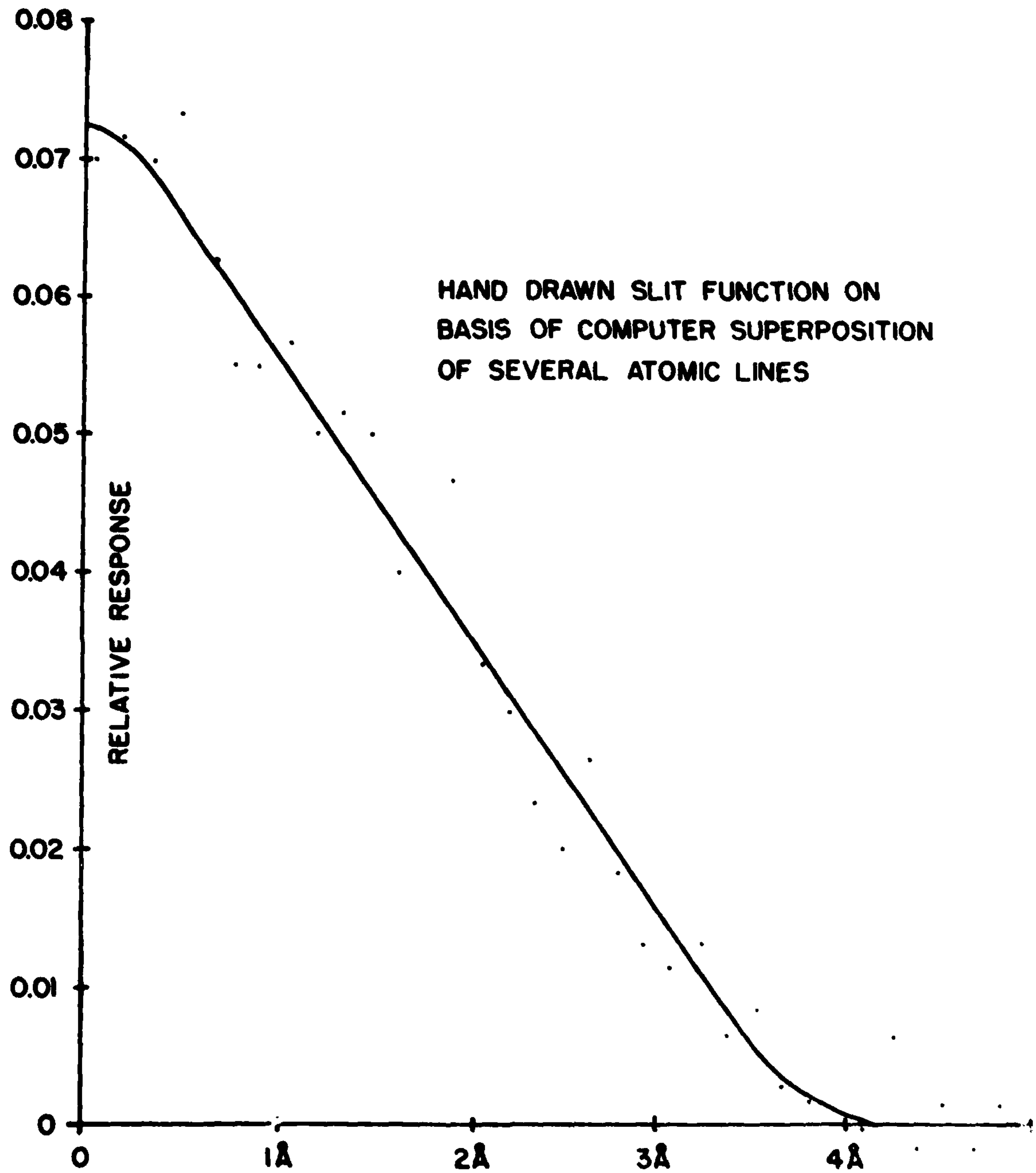


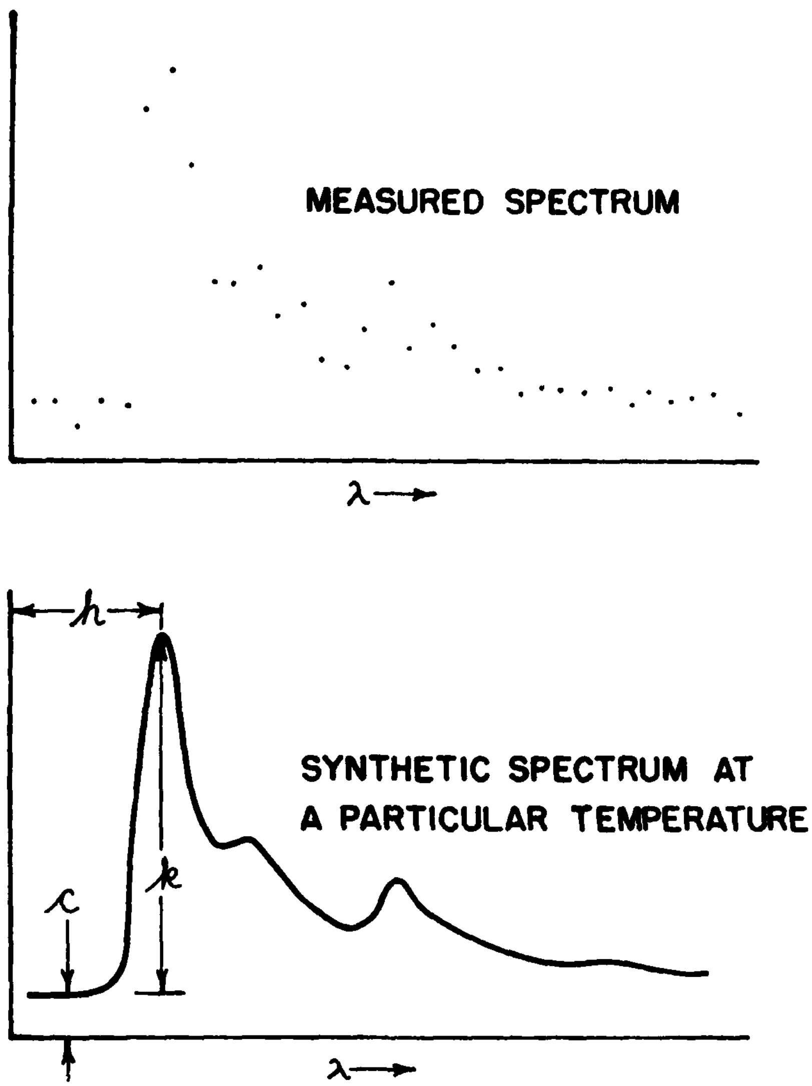
Figure 9. Slit Function Curve

Assuming dynamic equilibrium between vibrational levels and between rotational levels relative intensities can be assigned to each rotational line in the bands of a sequence.

The intensities of the first 75 rotational lines of each branch (P and R branches) in the first three bands of the $\Delta V = 0$ sequence are then convolved with the experimentally measured slit function derived in KITSLIT. This convolution is then tabulated every 1/4 Å and every 50 degrees from 150°K to 1050°K and stored as a permanent file. Plots of synthetic spectra are shown in Appendix B.

10. Program MATCH is the heart of the data reduction scheme. Inputs to MATCH are synthetic spectra from SYN already convolved with the slit function at 19 temperatures and the digitized spectrometer output. Groups of scans are summed or lumped as determined by the examination of quick plots from KITQPL and the study of the boresight records. The spectrometer output is then corrected for amplitude non-linearity or dead-time with subroutine FKAY using constants supplied by program KITAU. Correction is then made for variation of sensitivity with respect to wavelength using a linear approximation derived from the calibration scans of the lightbox.

    The data points in the lumped measured scans are then compared to each of the 19 synthetic spectra. Iterative adjustments are made to the exact horizontal (wavelength) position of the measured scan, a multiplicative factor which scales the synthetic spectra to the measured scan, and an additive constant which is added under the synthetic spectra as a pedestal. The iterative adjustments of the three variables described above and shown graphically in Figure 10 are made using as a criterion for best fit of the measured points to the synthetic curve the likelihood that the measured points result from a curve



ADJUSTMENTS TO OBTAIN OPTIMUM FIT

c = ADDITIVE CONSTANT = BACKGROUND PEDESTAL

k = MULTIPLICATIVE CONSTANT = SCALING FACTOR

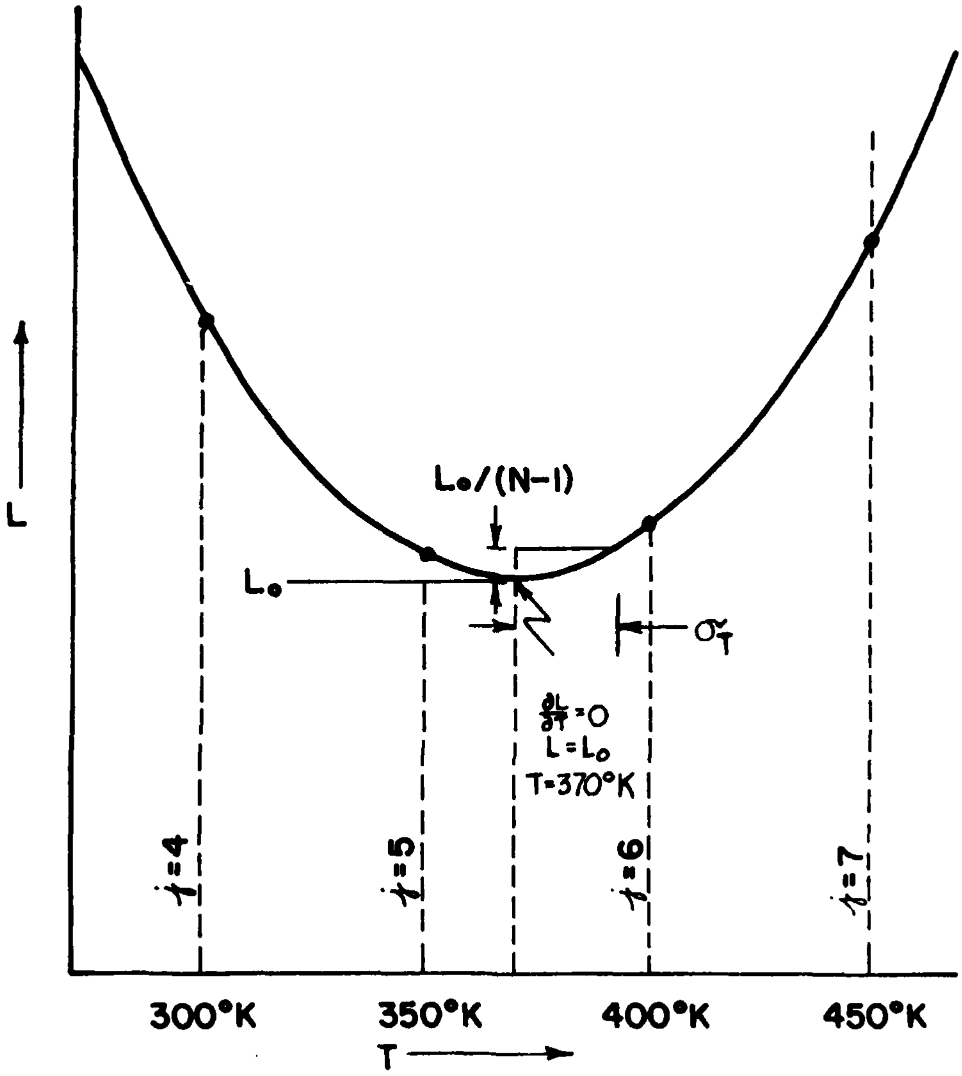
h = HORIZONTAL SHIFT = WAVELENGTH ADJUSTMENT

Figure 10. Adjustments Used in MATCH

same as the synthetic but made noisy according to Poisson statistics. The likelihood function is the product of the probabilities at each point in the measured scan that the point results from Poisson distributed errors about a point at the same wavelength in the synthetic spectrum. Incidentally, this type of maximum likelihood function procedure simplifies to become a least square fit when the errors in the measurement are Gaussian. It has been determined that in this application, involving counting randomly arriving photons which is properly described by Poisson statistics, with a fairly low number of counts at each point in the measured spectrum, considering that Gaussian statistics become a poorer approximation to Poisson statistics at smaller counts with a consistent bias from the skewed nature of the Poisson distribution and that the temperature deduced by this technique varies monotonically with the slope of the data points, use of least squares fitting rather than the maximum likelihood technique based on Poisson statistics results in a systematic error of as much as 15 degrees.

The temperature of the synthetic spectrum producing the maximum likelihood function as well as the next higher and next lower temperature and the three corresponding values of the likelihood function are used to generate a parabolic curve for a parabolic interpolation (see Figure 11). The peak of this parabola is used as the interpolated temperature of best fit. More details are supplied in Appendix A.

In Appendix B plots of the fourteen "lumped" or summed scans of measured spectra are shown along with five synthetic spectra closest in temperature to each of the measured spectra. The measured spectra are corrected for dead-time amplitude non-linearity and the variation of instrumental sensitivity with respect to wavelength.



WHERE:

N = NO. OF INDEPENDENT MEASUREMENTS

σ_T = STD. DEVIATION OF TEMPERATURE MEASUREMENT

L = SUM OF SQUARES (OR EQUIVALENT FOR POISSON STATISTICS)

T = TEMPERATURE

Figure 11. Interpolation of MATCH Results (Example)

The measured spectra as well as the five synthetic spectra are normalized to peak at 100 on the two decade 1 to 100 scale. The synthetic spectra are shown "sitting on top of" a pedestal C_j/k_j where C_j and k_j are the constants derived by the fitting procedure for best match of the particular synthetic spectrum to the measured spectrum. Even though only the region from 4824 Å to 4886 Å is used in the fitting procedure, more of the measured spectrum including part of the spectrometer return sweep is shown on the plot.

4.0 RESULTS

The results of the September 1977 White Sands temperature measurements are summarized in Table 3. Since there was only one puff or cloud, the data was taken from points near the top and near the bottom of the cloud rather than from the center of each in a series of small puffs as would usually be done in this sort of experiment. An average temperature for the observations of the top of the cloud weighted by $1/\sigma^2$ is 622°K with an overall σ of 22°K. Disregarding the three weak measurements where there may have been instrumental problems, the average is 628°K with a σ of 16°K. An average temperature for the observations of the bottom of the cloud with or without the two weak measurements was 578°K with an overall σ of 14°K.

Some of the scatter of individual measurements, particularly at the bottom of the cloud, is a result of having in the line of sight to the bottom, the more rapidly diffusing upper part of the cloud. In general, only the earliest measurements of AlO at altitudes as high as these are accurate for reasons of altitude spread along the line of sight through the cloud.

Better altitude resolution could have been had if the elevation angle of the line of sight were to have been lower; however, in the case of the White Sands site the logistic requirements precluded moving the observation site back 100-200 km as would have been preferred. Also the accident of having a very large release over perhaps 7-10 km rather than the smaller "point" releases did not aid the altitude precision either.

WSMR A10 TEMPERATURE

24 September 1977

File No. 2 AMUL = 0.3010 Calculations 19 June 78

Description	Scan No.	Sum	Peak	Max. Amp.		Time	Temp. [°K]	σ
TOP 1	8	7	210.5	117		11:59:38	650	6
BOT 1	16	8	207.4	63		12:00:21	571	8
BOT 2	24	8	204.2	80		12:01:01	574	7
BOT 3	32	8	201.5	101		12:01:41	601	7
TOP 2	49	5	194.9	210		12:02:58	621	6
BOT 4	54	3	193.8	130		12:03:18	606	11
BOT 5	58	9	191.5	13	Weak	12:03:53	600	20
TOP 3	68	8	186.1	23	Weak	12:04:41	574	16
TOP 4	76	9	183.5	23	Weak	12:05:23	594	13
TOP 5	86	5	179.7	23	Weak	12:06:03	575	18
BOT 6	93	6	177.9	11	Weak	12:06:41	572	29
BOT 7	100	8	175.0	91		12:07:21	569	6
BOT 8	122	11	166.2	78		12:09:18	570	5
TOP 6	136	7	160.0	118		12:10:18	614	6

TABLE 3

5.0 REFERENCES

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APPENDIX A

STATISTICAL DEVELOPMENT OF FITTING PROCEDURE

APPENDIX A

The general likelihood function where the error distributions at each point are independent is

$$L_j = \prod_{i=1}^{n} P_{\lambda ij}(y_i) \tag{1}$$

where y_i = table of values representing measurements at successive points in the measured spectrum.

$P_{\lambda ij}(y_i)$ = the probability that a point in the spectrum having a long term average λ_{ij} would be measured as y_i in a single measurement.

$$\lambda_{ij} = k_j z_{ij} + C_j \tag{2}$$

where z_{ij} = table of values of synthetic spectra at wavelengths corresponding to y_i at the same i index and temperature j.

k_j = an arbitrary multiplicative factor used to scale the synthetic spectrum to the measured spectrum and will be optimized to obtain the maximum likelihood at a given j.

C_j = an arbitrary additive constant added to the synthetic spectrum to represent a constant background or pedestal under the measured spectrum. It will be optimized same as k_j.

In this case where the distribution of individual measurements about a long term average is a Poisson distribution

$$P_{\lambda ij}(y_i) = \frac{(\lambda_{ij})^{y_i} \, \ell^{-\lambda_{ij}}}{(y_i)!} \tag{3}$$

Combining (1), (2) and (3) and taking the logarithm of both sides

$$\ell n\ L_j = \sum_{i=1}^{n} [y_i\ \ell n(k_j\ z_{ij} + C_j) - (k_j\ z_{ij} + C_j) - \ell n(y!)] \quad (4)$$

It is necessary now to find the maximum likelihood of $\ell n\ L_j$ as a function of k_j, C_j and j independently. The third term in (4) is not a function of the above so it can be ignored for the time being. At any given j then the optimum k_j and C_j are those which allow the partial derivatives below (5), (6) to be zero

$$\frac{\partial\ \ell n\ L_j}{\partial\ k_j} = 0 = \sum_{i=1}^{n} [\frac{y_i\ z_{ij}}{k_j\ z_{ij} + C_j} - z_{ij}] \quad (5)$$

$$\frac{\partial\ \ell n\ L_j}{\partial\ C_j} = 0 = \sum_{i=1}^{n} [\frac{y_i}{k_j\ z_{ij} + C_j} - 1] \quad (6)$$

Unfortunately there is no analytic solution for k_j and C_j as in the analogous procedure for a Gaussian distribution (least squares). The Newton Rapsohn method will be used to effect a solution.

$$f_j(k_j,C_j) = 0 = \sum_{i=1}^{n} \frac{y_i\ z_{ij}}{k_j\ z_{ij} + C_j} - \sum_{i=1}^{n} z_{ij} \quad (7)$$

$$g_j(k_j,C_j) = 0 = \sum_{i=1}^{n} \frac{y_i}{k_j\ z_{ij} + C_j} - n \quad (8)$$

in general

$$f(k_0 + \delta_K,\ C_0 + \delta_C) = 0 = f(k_0,C_0) + \delta_K \frac{\partial f(k_0,C_0)}{\partial k} + \delta_C \frac{\partial f(k_0,C_0)}{\partial C} \quad (9)$$

$$g(k_0 + \delta_k,\ C_0 + \delta_C) = 0 = g(k_0,\ C_0) + \delta_K \frac{\partial g(k_0,C_0)}{\partial k} + \delta_C \frac{\partial g(k_0,C_0)}{\partial C} \quad (10)$$

solving the right-hand side of both equations.

$$\delta_K = \frac{g\frac{\partial b}{\partial c} - f\frac{\partial g}{\partial c}}{\frac{\partial b}{\partial k}\frac{\partial g}{\partial c} - \frac{\partial f}{\partial c}\frac{\partial g}{\partial k}} \tag{11}$$

$$\delta_C = \frac{f\frac{\partial g}{\partial k} - g\frac{\partial f}{\partial k}}{\frac{\partial f}{\partial k}\frac{\partial g}{\partial c} - \frac{\partial f}{\partial c}\frac{\partial g}{\partial k}} \tag{12}$$

initial values of k_0 and C_0 are

$$k_0 = y_{max} - y_{min} \tag{13}$$

$$C_0 = y_{min} \tag{14}$$

new values for k and C are

$$k = k_0 + \delta_K \tag{15}$$

$$C = C_0 + \delta_C \tag{16}$$

which are iterated until $\delta K/k$ and δ_C/C are both less than 10^{-8} or so. Convergence to the 10^{-8} criteria takes five or six iterations.

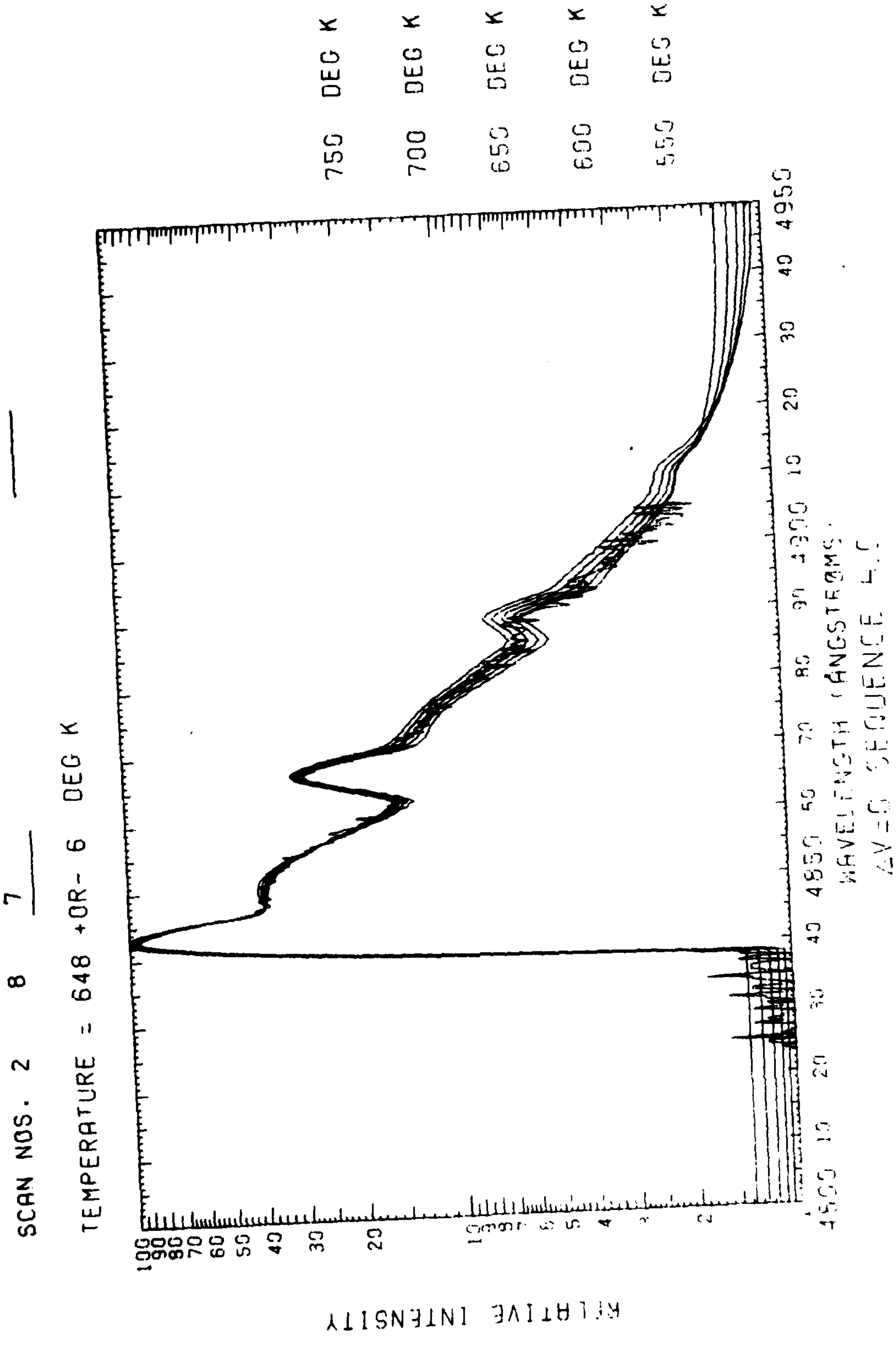
Once optimum k_j and C_j values are found corresponding to a particular T_j the actual likelihood function at each j can be computed. The T_j at which the likelihood function is maximum is the temperature of best fit. The preceding T_j along with T_{j+1} and T_{j+2} are used to generate a parabola

$$L = AT^2 + BT + C \tag{17}$$

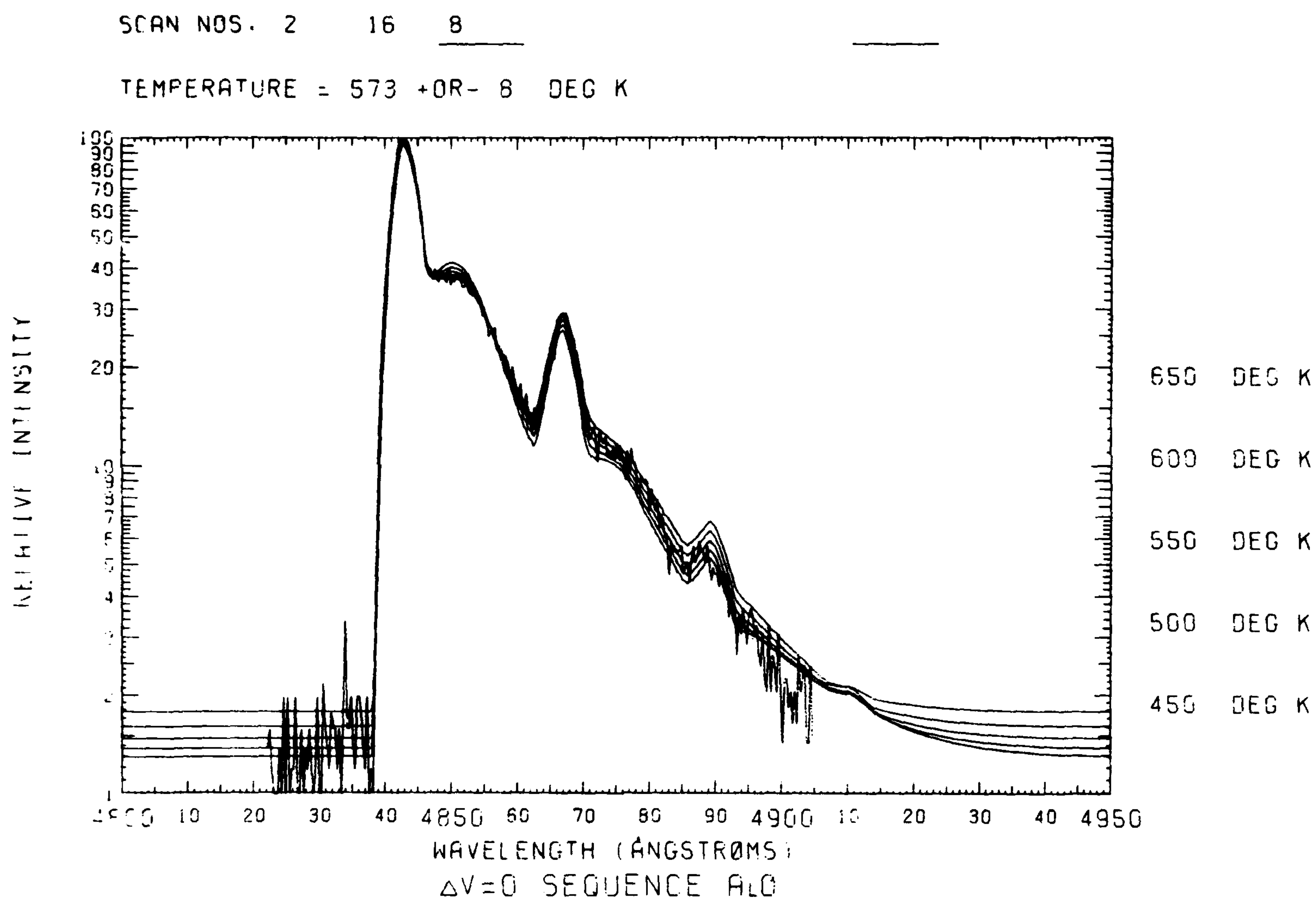
The peak of the parabola, where $\partial L/\partial T = 0$ is used to indicate an interpolated value of T. The shape of the parabola near the peak is used to deduce a σ_T in a manner similar to Dyer (1970, unpublished) for least squares fitting (see Figure 11).

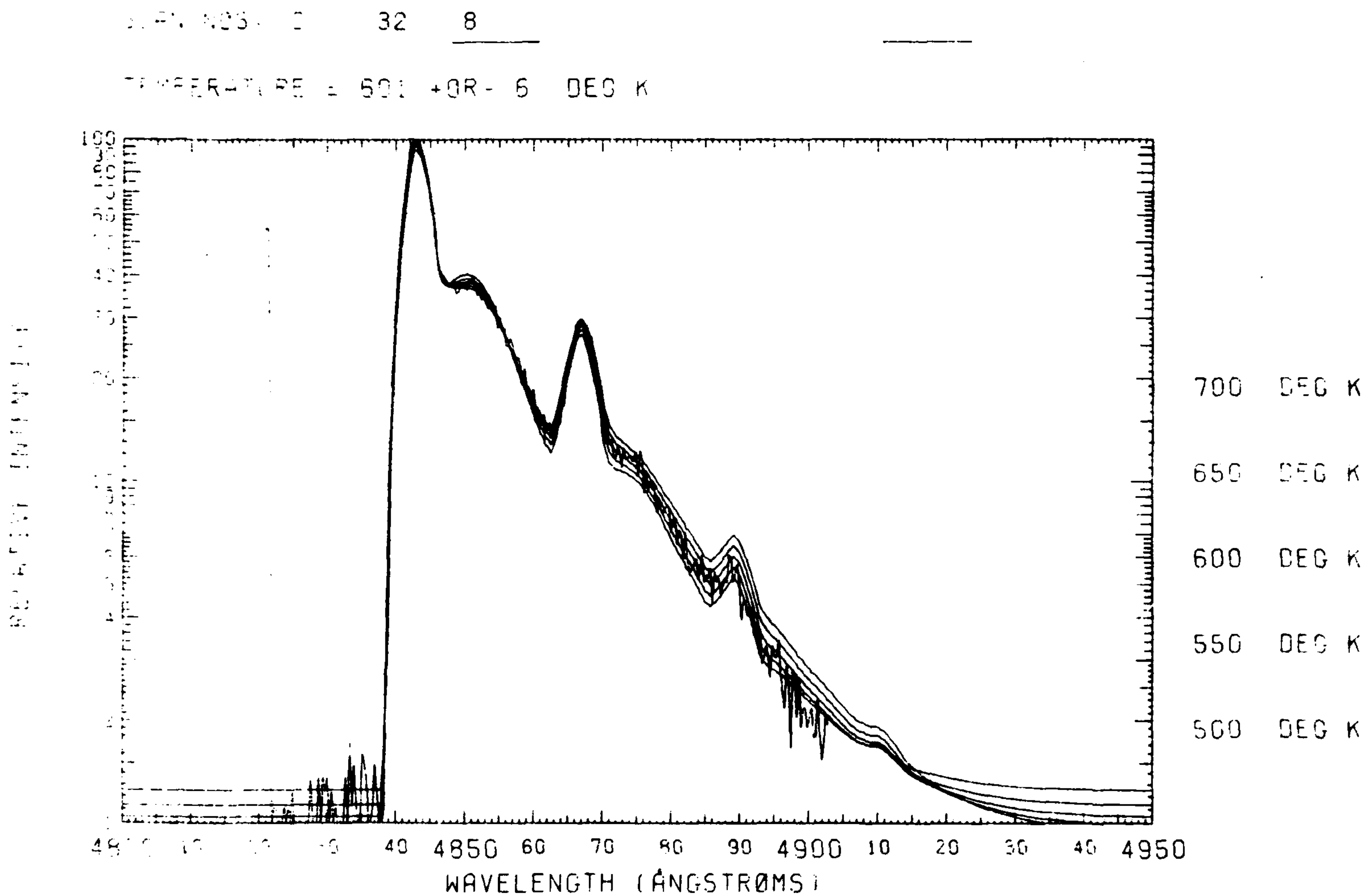
A P P E N D I X B

VISUAL VERIFICATION OF MATCH RESULTS



SCAN NOS. 2 8 7
TEMPERATURE = 648 +OR- 6 DEG K
750 DEG K
700 DEG K
650 DEG K
600 DEG K
550 DEG K
RELATIVE INTENSITY
WAVELENGTH (ANGSTROMS)
4850
4900
4950

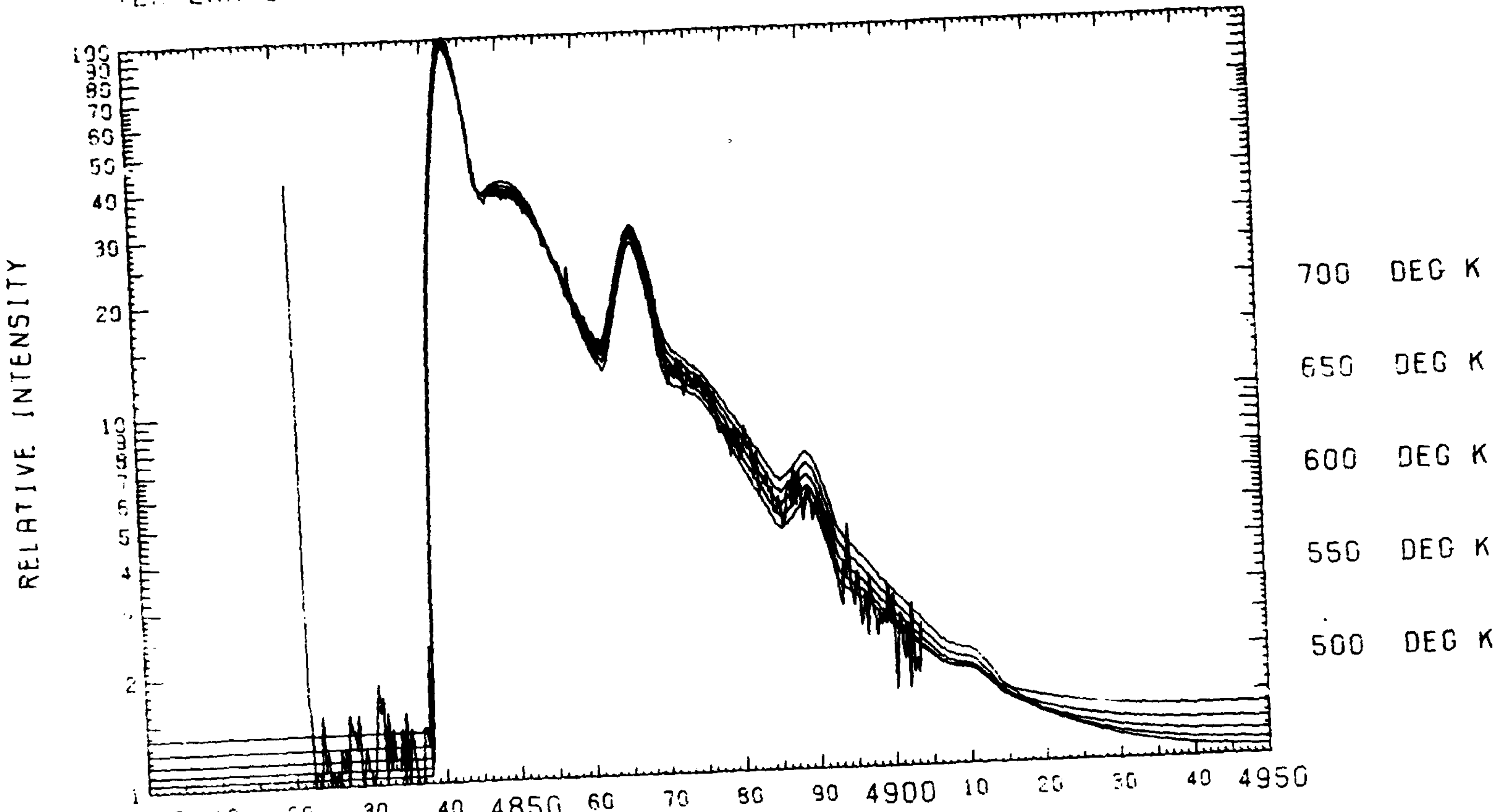

SCAN NOS. 2 16 8
TEMPERATURE = 573 +OR- 8 DEG K
RELATIVE INTENSITY
100
90
80
70
60
50
40
30
20
10
4
1
4800 10 20 30 40 4850 60 70 80 90 4900 10 20 30 40 4950
WAVELENGTH (ÅNGSTRØMS)
ΔV=0 SEQUENCE AlO
650 DEG K
600 DEG K
550 DEG K
500 DEG K
450 DEG K



ΔV=0 SEQUENCE AlO

SCAN NOS. 2 24 8

TEMPERATURE = 578 +OR- 7 DEG K

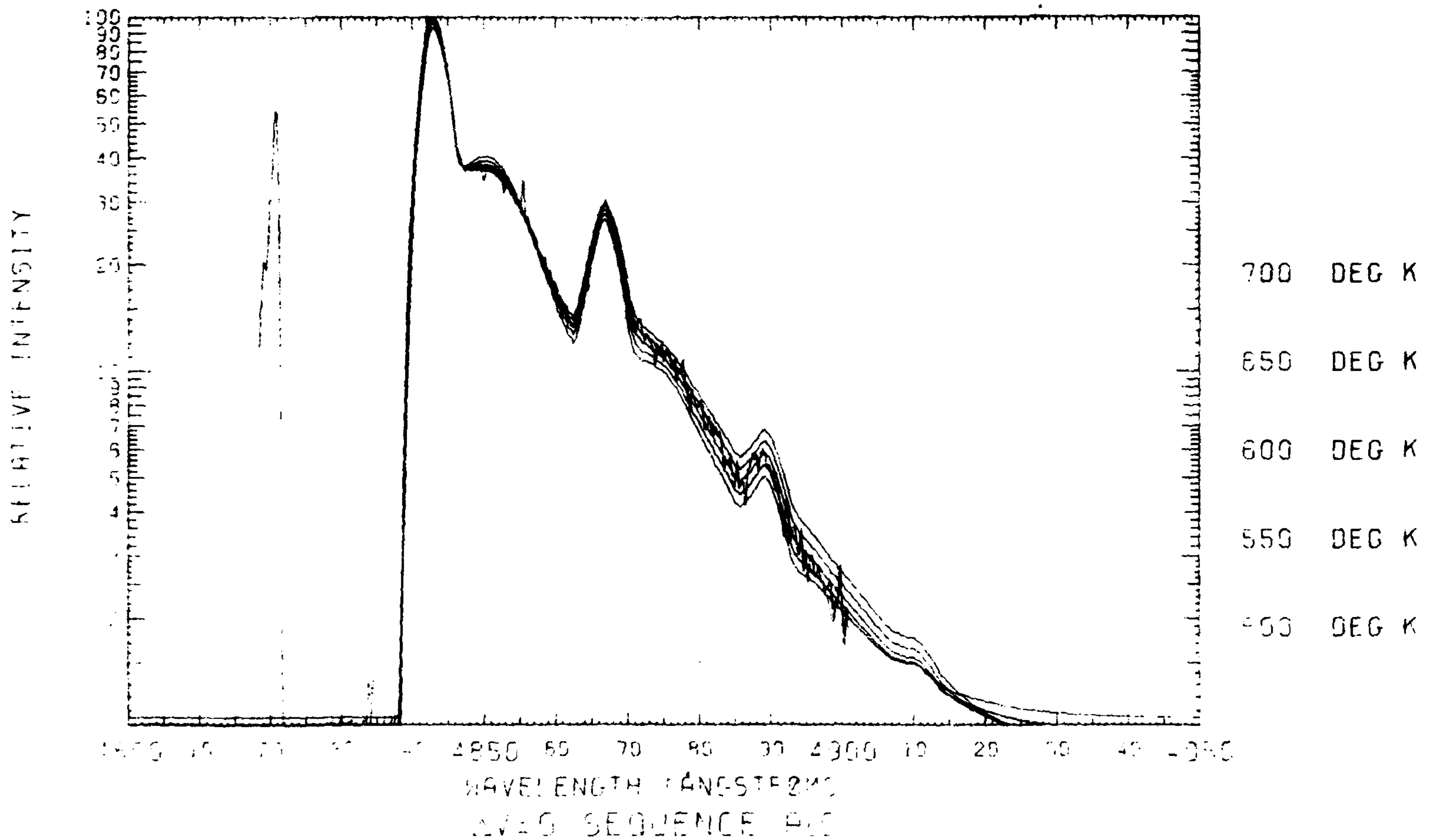


WAVELENGTH (ANGSTRØMS)

ΔV=0 SEQUENCE AlO

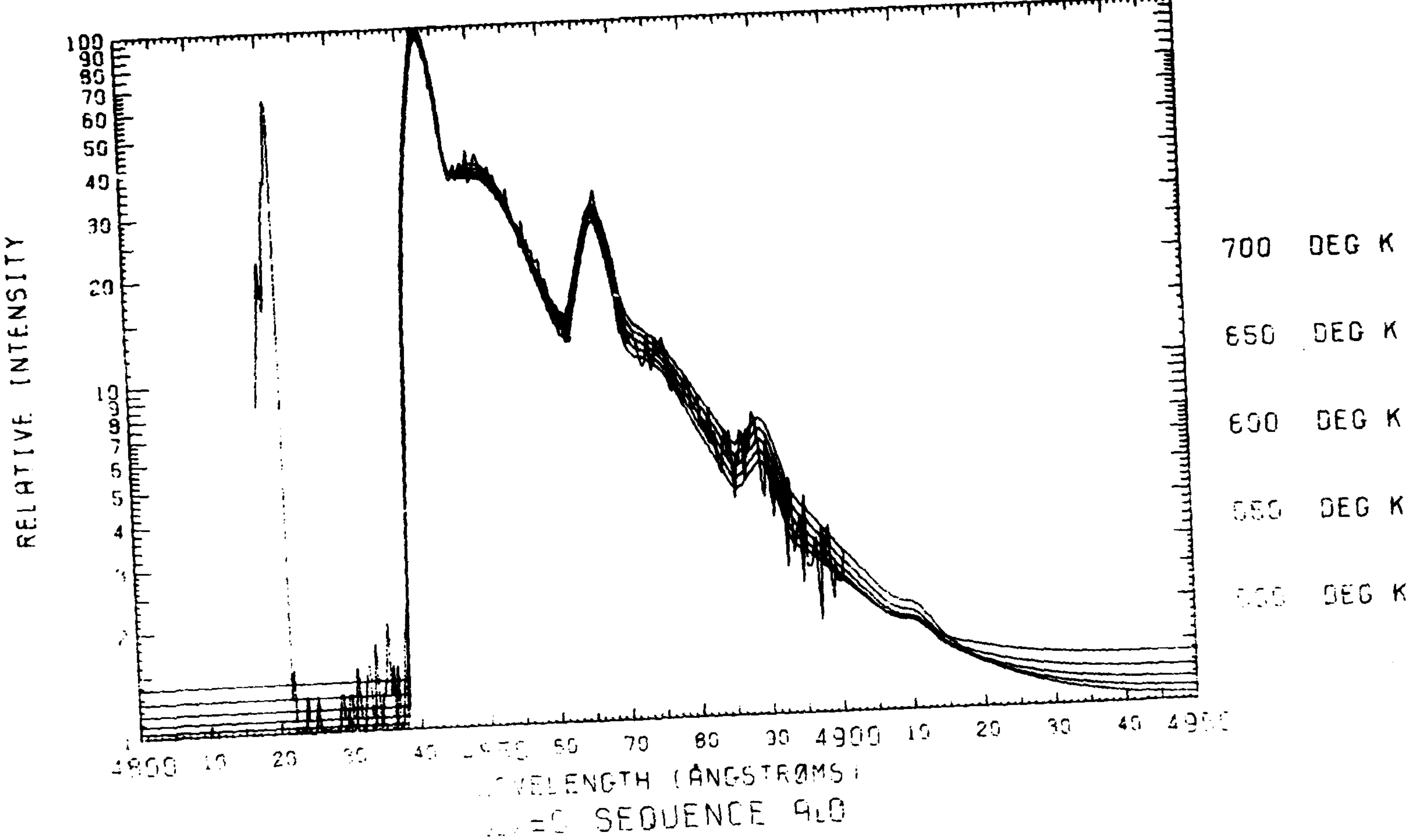
SCAN NOS. 2 49 5

TEMPERATURE = 621 +OR- 6 DEG K



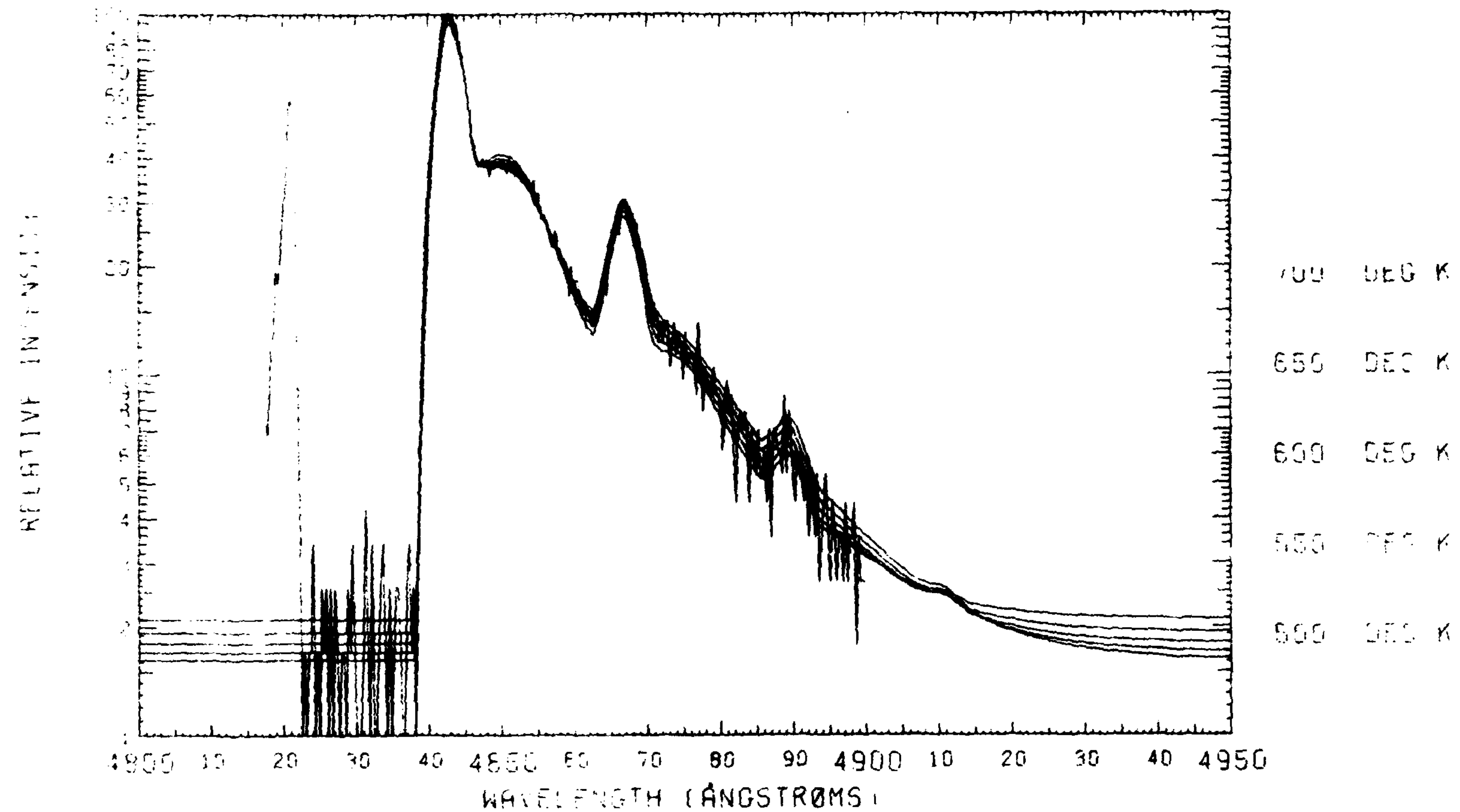
SCAN NOS. 2 54 3

TEMPERATURE = 602 +OR- 11 DEG K



SCAN NOS. 2 58 9

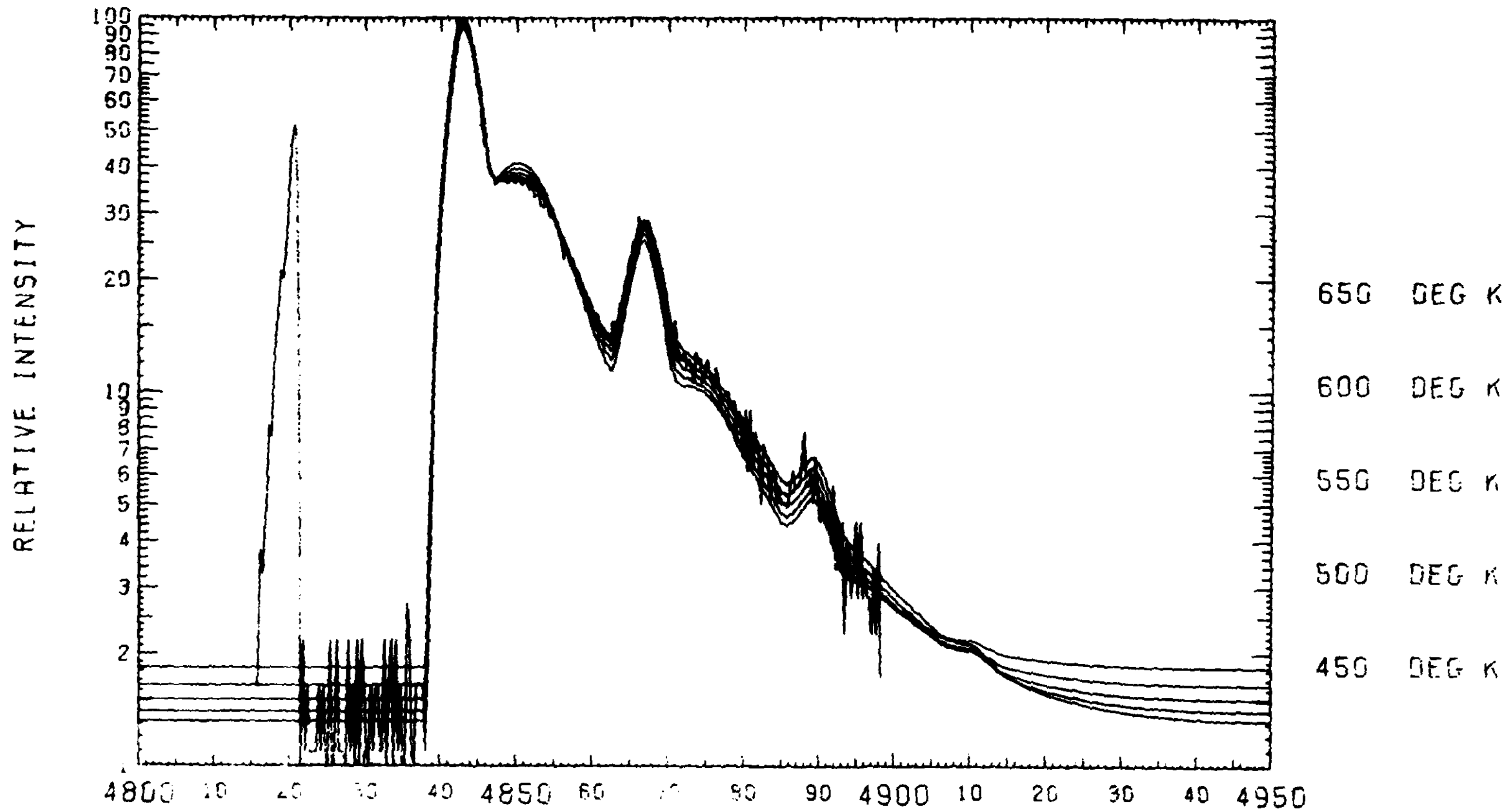
TEMPERATURE = 600 +OR- 19 DEG K



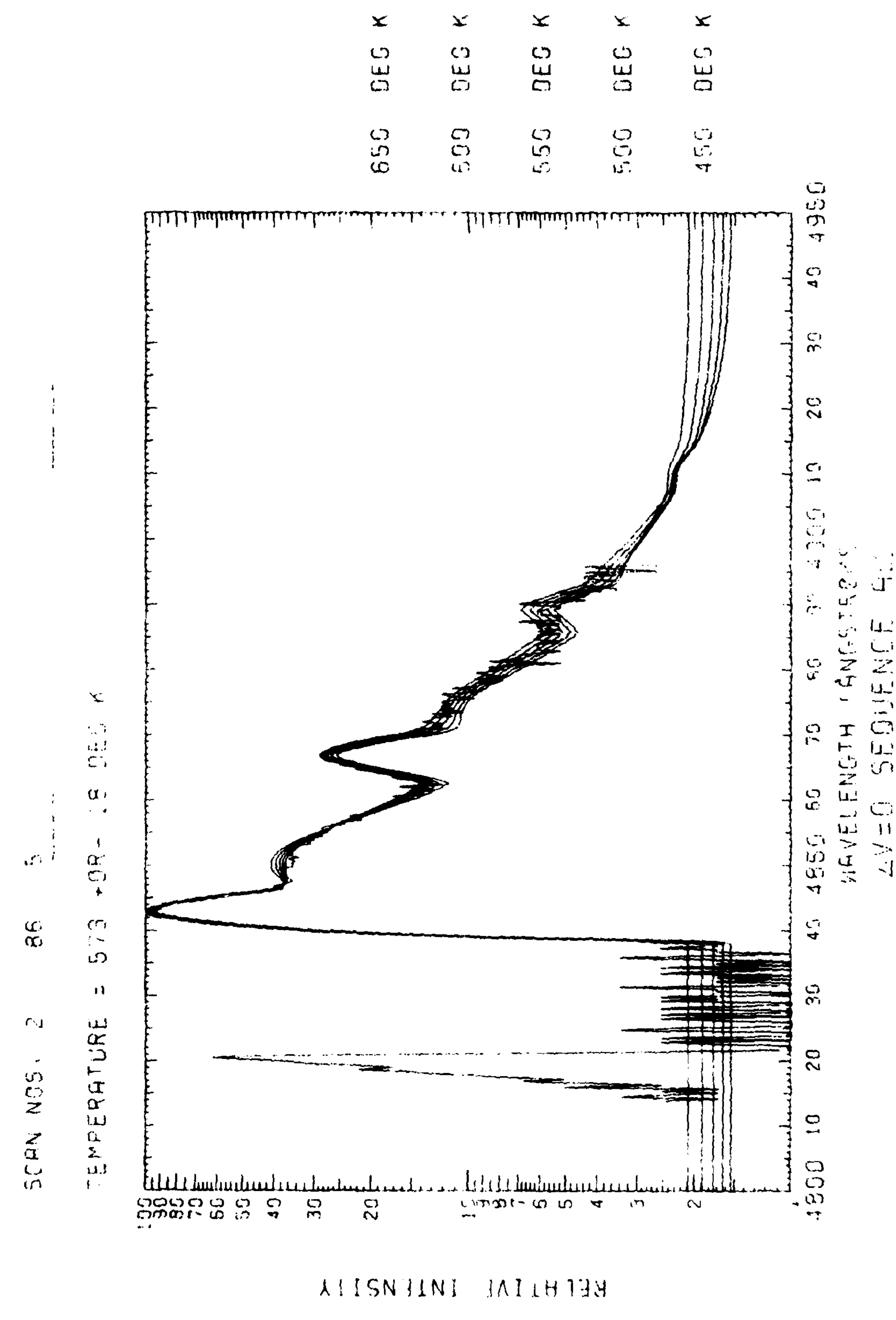
ΔV=1 SEQUENCE ALO

SCAN NOS. 2 68 8

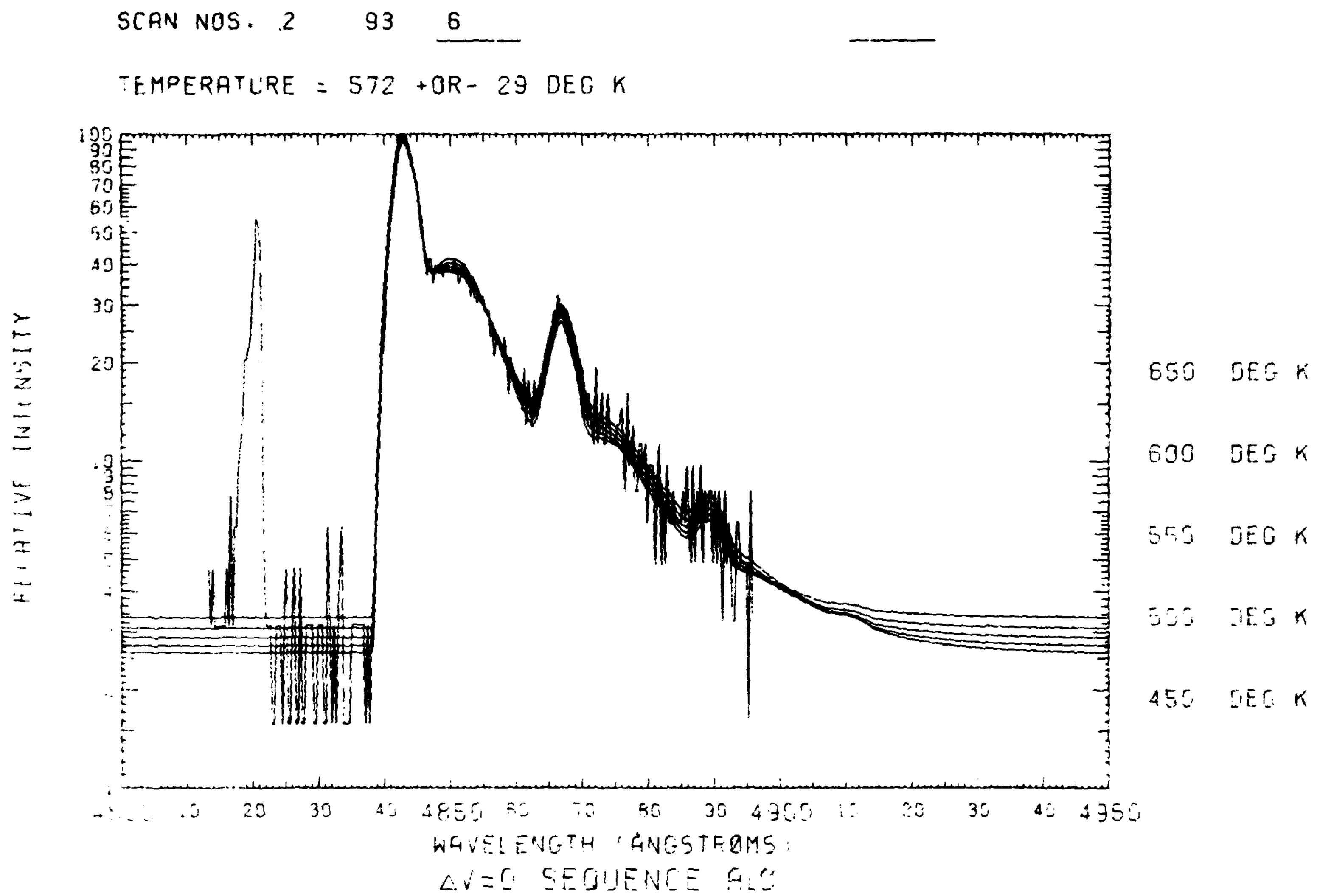
TEMPERATURE = 574 +OR- 15 DEG K

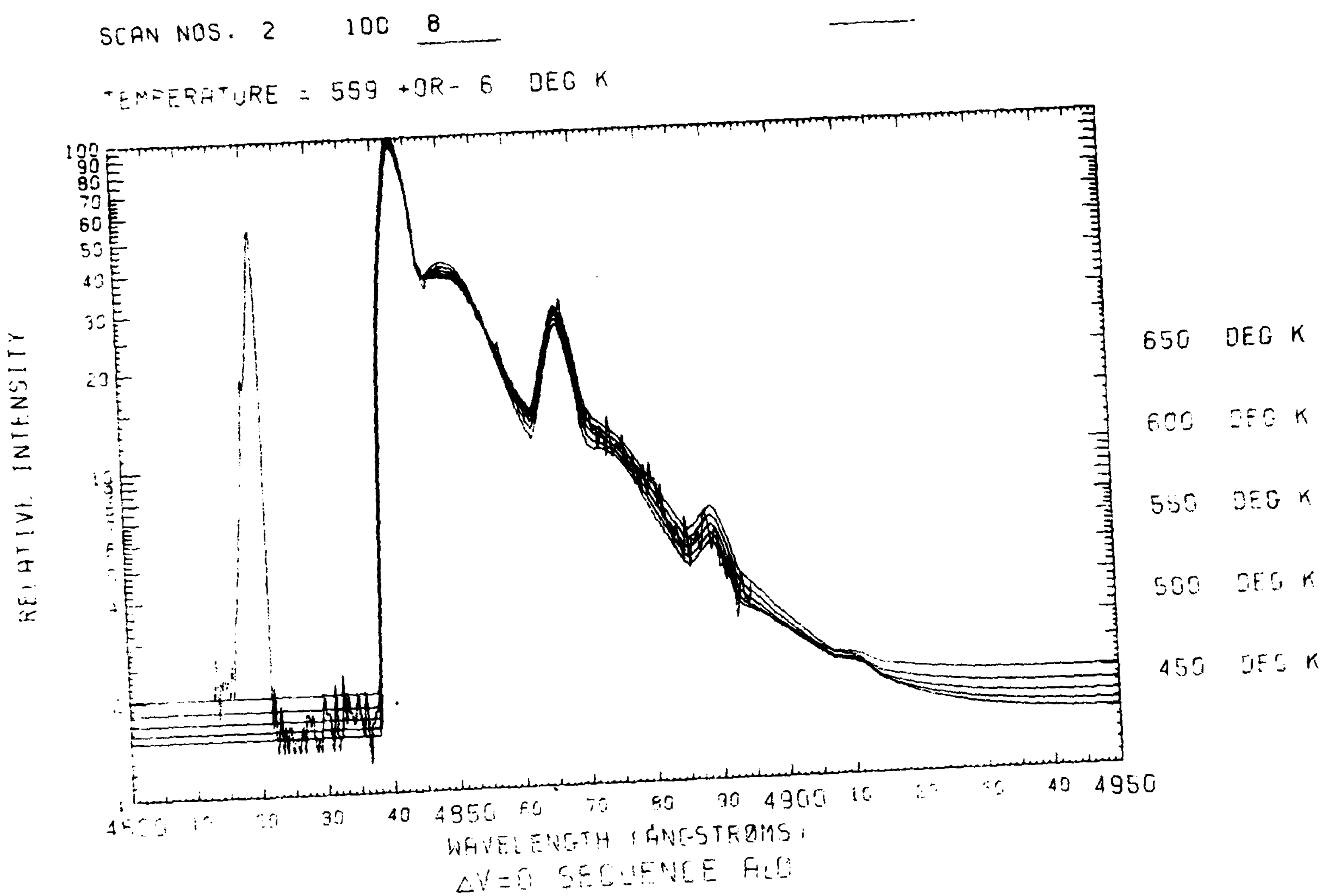


ΔV=0 SEQUENCE AlO



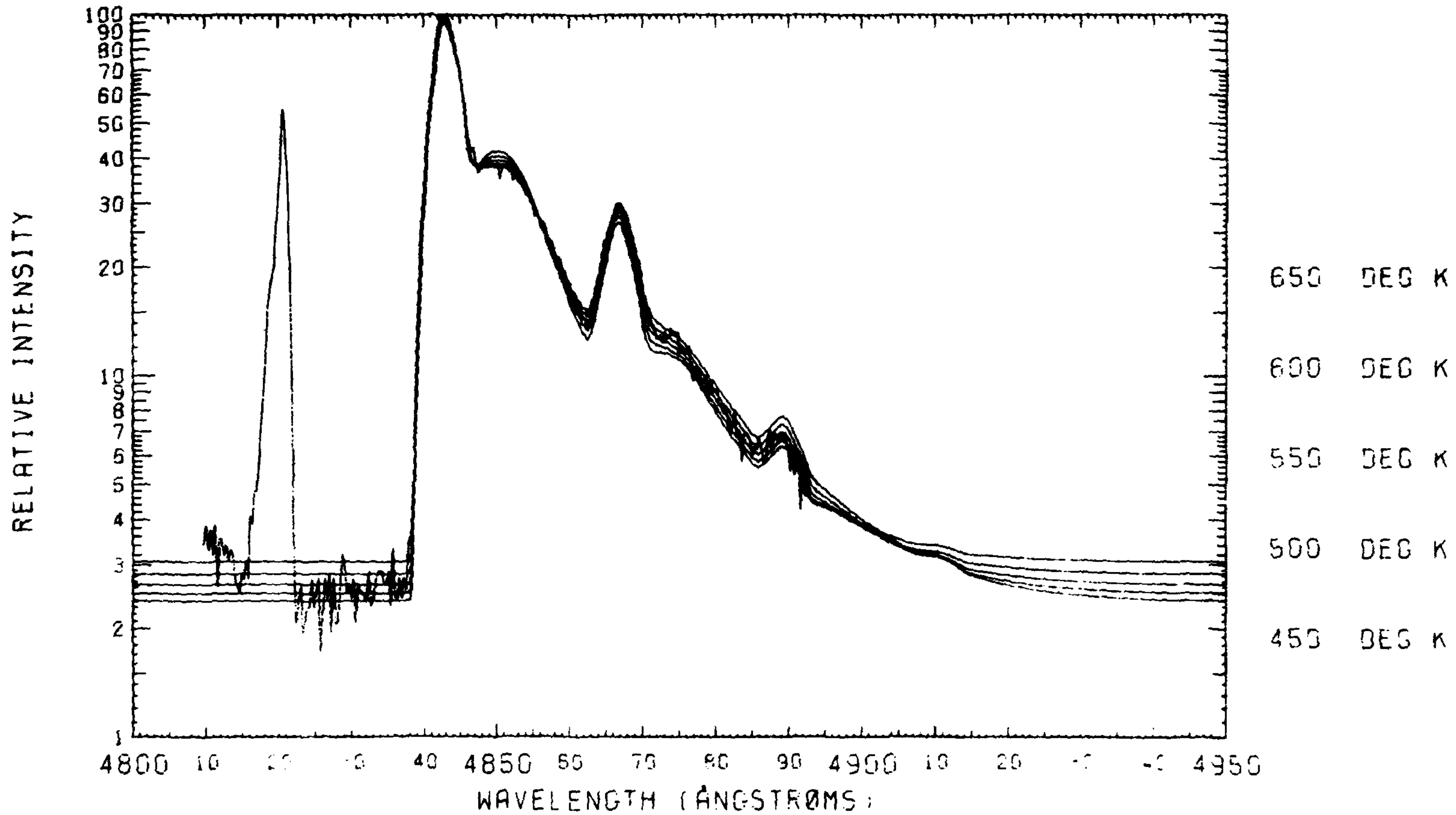
SCAN NOS. 2 86 5
TEMPERATURE = 573 +OR- 18 DEG K
650 DEG K
600 DEG K
550 DEG K
500 DEG K
450 DEG K
WAVELENGTH (ANGSTROMS)
RELATIVE INTENSITY


SCAN NOS. 2 93 6
TEMPERATURE = 572 +OR- 29 DEG K
RELATIVE INTENSITY
100
90
80
70
60
50
40
30
20
10
650 DEG K
600 DEG K
550 DEG K
500 DEG K
450 DEG K
10
20
30
40
4850
60
70
80
90
4900
10
20
30
40
4950
WAVELENGTH (ANGSTRØMS)
ΔV=0 SEQUENCE ALO


SCAN NOS. 2 100 8
TEMPERATURE = 559 +OR- 6 DEG K
RELATIVE INTENSITY
WAVELENGTH (ANGSTRØMS)
ΔV=0 SEQUENCE AlO
650 DEG K
600 DEG K
550 DEG K
500 DEG K
450 DEG K

SCAN NOS. 2 122 11

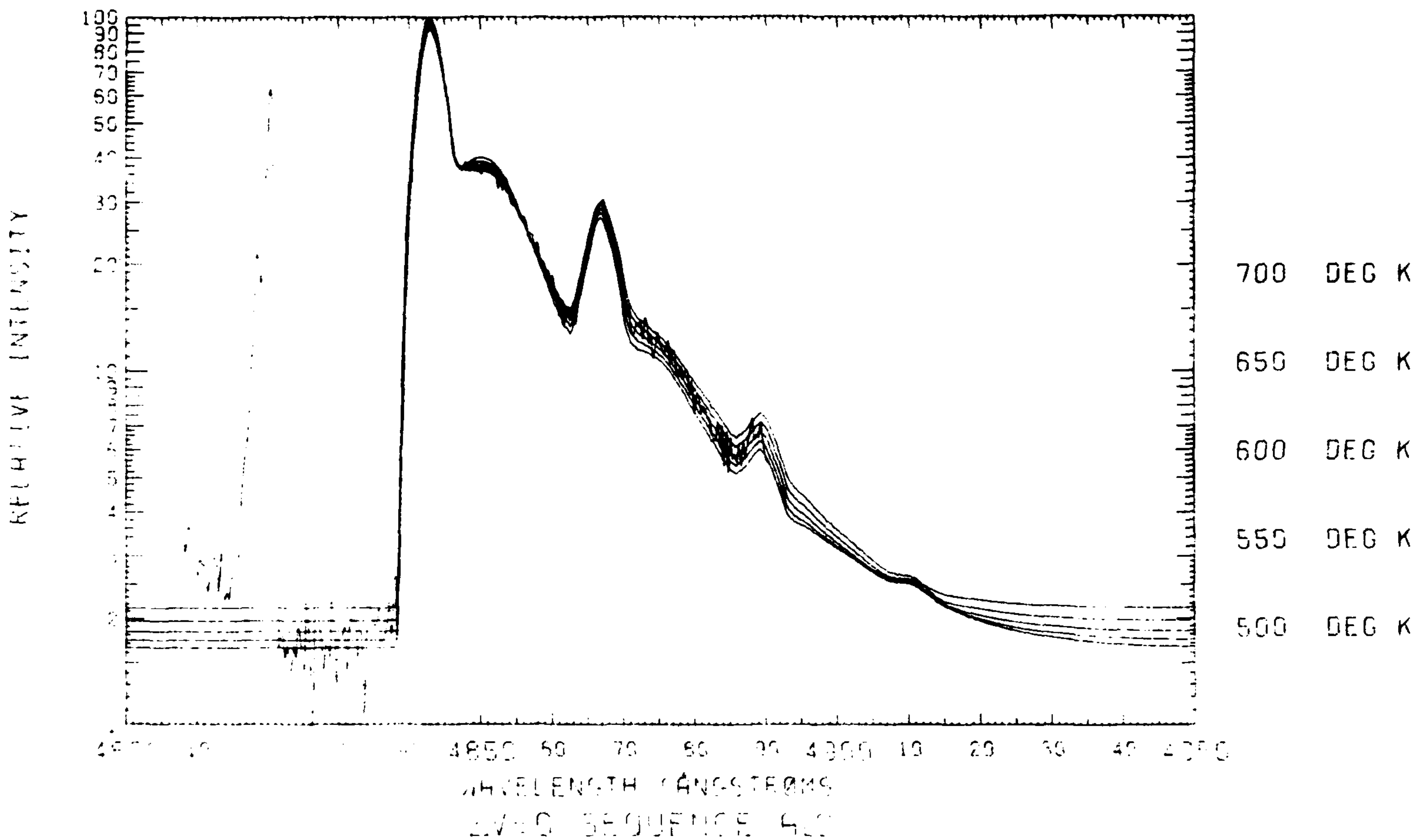
TEMPERATURE = 570 +OR- 5 DEG K



ΔV=0 SEQUENCE AlO

SCAN NOS. 2 136 7

TEMPERATURE = 611 +OR- 6 DEG K



A P P E N D I X C

LISTING OF COMPUTER PROGRAMS

```
      PROGRAM ABP(OUTPUT,TAPE5,TAPE6,TAPE3,TAPE7,TAPE39)
CC    PROGRAM THEO
      DIMENSION TE(2),W(2),WX(2),WY(2),BE(2),ALFA(2),IZ(28),IIZ(28)
      DIMENSION FC(8,8),R(8,8),SNV(8),SNJ(8,80),EMI(8,80),APS(8,80)
      DIMENSION FR(3,3,80),FP(3,3,80),JEX(8)
      DIMENSION MJR(80),MJQ(80),MJP(80),BLAP(80),BIP(80),BLAR(80),
     1BIR(80)
      COMMON TE,W,WX,WY,BE,ALFA
      COMMON/SPECTP/BLAP,BLAR,BIP,BIR
      WRITE(6,297)
  297 FORMAT (38H1ALO PROGRAM 1968 FOLLOWING DATA USED )
      REWIND   7
      READ(5,295)IDATE,MOG
      WRITE(6,2951)IDATE,MOG
  295 FORMAT(I6,I2)
 2951 FORMAT(1X,I6,I2)
      READ (5,296)(JEX(IJEX),IJEX=1,5)
      WRITE(6,296)(JEX(IJEX),IJEX=1,5)
  296 FORMAT(1H ,5A10)
      READ(5,109)TSOL,YSOL,SOLO
      WRITE(6,1091)TSOL,YSOL,SOLO
  109 FORMAT(2F10.0,E12.4)
 1091 FORMAT(1X,2F10.0,E12.4)
      READ(5,111)(TE(I),W(I),WX(I),WY(I),BE(I), ALFA(I),I=1,2)
      WRITE(6,1111)(TE(I),W(I),WX(I),WY(I),BE(I), ALFA(I),I=1,2)
  111 FORMAT(F12.4,F11.5,F12.7,F9.6,F9.7,F10.7)
 1111 FORMAT(1X,F12.4,F11.5,F12.7,F9.6,F9.7,F10.7)
      READ(5,112)G,IMAX,JMAX
      WRITE(6,1121)G,IMAX,JMAX
  112 FORMAT(F20.3,2I3)
 1121 FORMAT(1X,F20.3,2I3)
      DO 113  I=1,IMAX
      DO 113 II=1,IMAX
      READ(5,114)L,LL,FC(I,II),R(I,II)
      WRITE(6,1141)L,LL,FC(I,II),R(I,II)
  114 FORMAT (2I2,E11.4,F7.3)
 1141 FORMAT(1X,2I2,E11.4,F7.3)
  113  CONTINUE
      READ(5,122)M,IAX,IIAX,JNAX
      WRITE(6,1221)M,IAX,IIAX,JNAX
  122 FORMAT(4I3)
 1221 FORMAT(1X,4I3)
      IF(M)127,127,1233
  127 DO 128 I=1,IAX
      DO 128 II=1,IIAX
      DO 128 J=1,JNAX
      READ(5,180)IA,IB,LQ,JP,TP,FP(I,II,J),JQ,JR,TR,FR(I,II,J)
      WRITE(6,1801)IA,IB,LQ,JP,TP,FP(I,II,J),JQ,JR,TR,FR(I,II,J)
  180 FORMAT(2I3,I4,I3,F10.2,F10.3,2I3,F10.2,F10.3)
 1801 FORMAT(1X,2I3,I4,I3,F10.2,F10.3,2I3,F10.2,F10.3)
  128  CONTINUE
 1233 READ(5,193)LL,JKAX
      WRITE(6,1931)LL,JKAX
      READ (5,193 )(IZ(L),IIZ(L),L=1,LL)
      WRITE(6,1931)(IZ(L),IIZ(L),L=1,LL)
  193 FORMAT (14I4)
 1931 FORMAT(1X,14I4)
      READ(5,115)T,DELT,TMAX
      WRITE(6,1151)T,DELT,TMAX
      TBEGIN=T
  115 FORMAT (3F10.1)
 1151 FORMAT(1X,3F10.1)
  292 FORMAT (26H THESE DATA ON TAPE IF 1 =,I2)
      WRITE(6,292)MOG
      READ(5,193 )ISPECP,ILINE,ICON,IINV
      WRITE(6,1931)ISPECP,ILINE,ICON,IINV
  123 CONTINUE
      GT=1.0/(0.6952*T)
      JAX=JMAX+1
      V=0.0
      Q=1.0
  116 V=V+1.0
      GO=(W(2)-WX(2))*V-WX(2)*V*V
      EX=EXP (-GO*GT)
      Q=Q+EX
      IF(EX*200.0-1.0)117,117,116
  117 QV=Q
      DO 120 L=1,IMAX
      VL=L-1
      GOO=(W(2)-WX(2))*VL-WX(2)*VL*VL
      VN=(1.0/QV)*EXP (-GOO*GT)
      SNV(L)=VN
  120 CONTINUE
      B=BE(2)-ALFA(2)*1.5
```

```
    D=4.0*BF(2)*BE(2)*BE(2)/(W(2)*W(2))
    AJ=0.0
    Q=1.0
146 AJ=AJ+1.0
    A=AJ*(AJ+1.0)
    FJ=B*A-D*A*A
    F=EXP (-FJ*GT)
    FA=(AJ+AJ+1.0)*F
    Q=Q+FA
    IF((FA*100.0/Q)-1.0)147,147,146
147 QJ=Q
    DO 148 I=1,IMAX
    V=I-1
    BB=BE(2)-ALFA(2)*(V+0.5)
    DO 148 J=1,JAX
    SJ=J-1
    S=(SJ+1.0)*SJ
    FS=BB*S-D*S*S
    F=EXP (-FS*GT)
    SF=(SJ+SJ+1.0)*F/QJ
148 SNJ(I,J)=SF
    SO=0.6952*TSOL
    SOL=SLOF(YSOL,SO)
    C=SOLO/SOL
    DO 355 I=1,IMAX
    DO 150 J=1,JMAX
    SUM=0.0
    DO 152 II=1,IMAX
    UR=1.0-G*R(I,II)
    FK=UR*UR*FC(I,II)
    SV=SNV(II)
    SIV=SV*FK
    TYR=SNY(I,II,J,J-1)
    TYP=SNY(I,II,J,J+1)
    IF(M)179,179,154
179 IF(I-IAX)174,174,154
174 IF(II-IIAX)178,178,154
178 IF(J-JNAX)176,176,154
176 FRR=FR(I,II,J)
    FRP=FP(I,II,J)
    GO TO 153
154 FRR=1.0
    FRP=1.0
153 IF(J-1)155,155,156
155 SIR=0.0
    GO TO 157
156 SJ=SNJ(II,J-1)
    CJ=J-1
    CCJ=2*(J-1)+1
    SR=CJ/CCJ
    SL=C*SLOF(TYR,SO)
    SIR=SJ*SR*TYR*SL*FRR
157 SSJ=SNJ(II,J+1)
    DJ=J
    DDJ=2*J+1
    SP=DJ/DDJ
    SSL=C*SLOF(TYP,SO)
    SIP=SSJ*SP*SSL*TYP*FRP
    SI=SIV*(SIP+SIR)
    SUM=SUM+SI
152 CONTINUE
    AFS(I,J)=SUM
150 CONTINUE
355 CONTINUE
    DO 160 I=1,IMAX
    DO 161 J=1,JMAX
    SUM=0.0
    DO 162 II=1,IMAX
    UR=1.0-G*R(I,II)
    FK=UR*UR*FC(I,II)
    IF(J-1)163,163,164
163 SIR=0.0
    GO TO 165
164 SR=J-1
    SYR=SNY(I,II,! J-1)
    S3R= SYR*SYR*SYR
    SIR=SR*S3R
165 SP=J
    SYP=SNY(I,II,J,J+1)
    S3P=SYP*SYP*SYP
    SIP=SP*S3P
    SI=(SIP+SIR)*FK
162 SUM=SUM+SI
161 EMI(I,J)=SUM
```

```
  160 CONTINUE
      BDN=2.726E-04
      SDN=1.-SDN
      WLMAX=0.
      WLMIN=100000.
      AMPMAX=0.
      DO 194 L=1,LL
      I=IZ(L)+1
      II=IIZ(L)+1
 1901 FORMAT(1X,I6,F10.1,4I4, F10.3,E15.4,2I4,F10.3,E15.4)
      RR=1.0-G*R(I,II)
      FK=FC(I,II)*RR*RR
      DO 168J=1,JKAX
      AE=AFS(I,J)/EMI(I,J)
  170 SR=J-1
  172 SP=J
      SNYP=SNY(I,II,J,J+1)
      SNYR=SNY(I,II,J,J-1)
      T3P=SNYP*SNYP*SNYP
      T3R=SNYR*SNYR*SNYR
      BLAP(J)=SDN*100000000/SNYP
      BLAR(J)=SDN*100000000/SNYR
      MJR(J)=J-2
      MJP(J)=J
      MJQ(J)=J-1
      BIP(J)=SP*AE*FK*T3P
      BIR(J)=SR*AE*FK*T3R
      IF(I.NE.II)GO TO 173
      IF(BIP(J).GT.AMPMAX)AMPMAX=BIP(J)
      IF(BIR(J).GT.AMPMAX)AMPMAX=BIR(J)
      IF(BIP(J).LT..001*AMPMAX)GO TO 1725
      IF(BLAP(J).GT.WLMAX)WLMAX=BLAP(J)
      IF(BLAP(J).LT.WLMIN)WLMIN=BLAP(J)
 1725 CONTINUE
      IF(BIR(J).LT..001*AMPMAX)GO TO 173
      IF(BLAR(J).GT.WLMAX)WLMAX=BLAR(J)
      IF(BLAR(J).LT.WLMIN)WLMIN=BLAR(J)
  173 CONTINUE
      IF(J.EQ.20)WRITE(6,1901)IDATE,T,IZ(L),IIZ(L),MJQ(J),MJP(J),BLAP(J)
     1,BIP(J),MJQ(J),MJR(J),BLAR(J),BIR(J)
  168 CONTINUE
      IF(MOG.EQ.1)WRITE(7      )(IDATE,T,IZ(L),IIZ(L),MJQ(J),MJP(J),BLAP(
     1J),BIP(J),MJQ(J),MJR(J),BLAR(J),BIR(J),J=1,JKAX)
      IF(L.EQ.1.AND.T.EQ.500.)WRITE(6,1901)(IDATE,T,IZ(L),IIZ(L),MJQ(J),
     1MJP(J),BLAP(J),BIP(J),MJQ(J),MJR(J),BLAR(J),BIR(J),J=1,JKAX)
  194 CONTINUE
      IF(IINV.EQ.1)CALL INVEN(LL,JKAX)
      IF(ISPECP.EQ.1)CALL SPECVC(WLMAX,WLMIN,LL,JKAX,JEX,T)
      T=T+DELT
      IF(T.LE.TMAX)GO TO 123
      BACKSPACE   7
      PRINT 1931, JKAX
      READ (   7) (ID,T,I1,I2,MJQ(J),MJP(J),BLAP(J),BIP(J),MJQ(J),
     1MJR(J),BLAR(J),BIR(J),J=1,JKAX)
      WRITE(6,1901)(ID,T,I1,I2,MJQ(J),MJP(J),BLAP(J),BIP(J),MJQ(J),
     1MJR(J),BLAR(J),BIR(J),J=1,JKAX)
      REWIND   7
      IF(ICON.EQ.1)CALL HCON(TBEGIN,TMAX,DELT)
  555 CONTINUE
      IF(ISPECP.EQ.1)CALL PLOTV(4)
      STOP
      END
C
C
C  4    SMALL SUBROUTINES
C
C
      FUNCTION SLOF(A,SO)
C     THEORETICAL SPECTRA
      SLOF=A*A/(EXP(A/SO)-1.0)
      RETURN
      END
      FUNCTION SNY(I,II,J,JJ)
      DIMENSION TE(2),W(2),WX(2),WY(2),BE(2),ALFA(2)
      COMMON TE,W,WX,WY,BE,ALFA
      V=I-1
      VV=II-1
      AJ=J-1
      AJJ=JJ-1
      G1=W(1)*(V+0.5)-WX(1)*(V+0.5)*(V+0.5)
      G2=W(2)*(VV+0.5)-WX(2)*(VV+0.5)*(VV+0.5)
      B1=BE(1)-ALFA(1)*(V+0.5)
      B2=BE(2)-ALFA(2)*(VV+0.5)
      [illegible]
```

```
      D2=4.0*BE(2)*BE(2)*BE(2)/(W(2)*W(2))
      AA=AJJ*(AJJ+1.0)
      A=AJ*(AJ+1.0)
      F1=B1*A-D1*A*A
      F2=B2*AA-D2*AA*AA
      T1=TE(1)+G1+F1
      T2=TE(2)+G2+F2
      SNY=T1-T2
      RETURN
      END
C
C
C  5   HCON
C
C
      SUBROUTINE HCON(T1,T2,T3)
      DIMENSION L(75),M(75),A(75),B(75),D(75),N(75),C(75)
      DIMENSION Y(801)
      REWIND 3
C
      DO 100 IPAS=1,1
C
      REWIND 7
      IV=0
      ST=4800.
      IT1=T1+.001  $  IT2=T2+.001  $  IT3=T3+.001
      DO 70 IT=IT1,IT2,IT3
    5 READ(7)(ID,T,IX,IY,L(J),M(J),A(J),B(J),L(J),N(J),C(J),D(J),J=1,75)
      IF((IX-IY).NE.IV)GO TO 5
      DO 6 K=1,801
    6 Y(K)=0.
      DO 11 LL=1,4
      IF(LL.EQ.1)GO TO 7
      READ(7)(ID,T,IX,IY,L(J),M(J),A(J),B(J),L(J),N(J),C(J),D(J),J=1,75)
    7 IF((IX-IY).NE.IV)GO TO 110
      ITT=T+.01
      IF(ITT.NE.IT)GO TO 110
      DO 11 I=1,2
      DO 11 J=1,75
      IF(I.EQ.2)A(J)=C(J)
      IF(I.EQ.2)B(J)=D(J)
      K1=4.*(A(J)-ST)-15.
      K2=K1+30
      IF(K1.LT.1)K1=1
      IF(K1.GT.800)K1=800
      IF(K2.LT.2)K2=2
      IF(K2.GT.801)K2=801
      DO 11 K=K1,K2
      VK=K-1
      DLAM=A(J)-.25*VK-ST
      Y(K)=Y(K)+B(J)*SLITFN(IPAS,DLAM)
   11 CONTINUE
      YM=0.
      DO 12 K=1,801
      IF(Y(K).GT.YM)KM=K
      IF(Y(K).GT.YM)YM=Y(K)
   12 CONTINUE
      DO 13 K=1,801
   13 Y(K)=Y(K)/YM
      WRITE(3)IV,T,IPAS,KM,(Y(K),K=1,801)
      PRINT 14,IV,T,IPAS,KM
   14 FORMAT(1X,16HSEQUENCE DELT V=,I2,7H, TEMP=,F6.0,13H DEG K, IPAS=,
     1I4,30H             BANDHEAD AT STEP NUM,I4)
   70 CONTINUE
      ENDFILE 3
      PRINT 71
   71 FORMAT(2H1*'
  100 CONTINUE
      GO TO 120
  110 PRINT 111
  111 FORMAT(1X,26HWRONG ORDER ON DISK,RETURN)
  120 RETURN
      END
C
C
C  6   SLITFN
C
C
      FUNCTION SLITFN(N,DLAM)
      DIMENSION FN(3,100),AMUL(3),LIM(3)
      DATA(FN(1,K),K=1,20)/5.54,5.50,5.40,5.22,4.90,4.56,4.12,3.64,3.22,
     12.76,2.30,1.86,1.42,1.00,.74,.48,.28,.16,.06,0./
      DATA(FN(2,K),K=1,14)/7.93,7.83,7.37,6.52,5.74,4.97,4.2,3.32,2.54,
     11.74,1.,.32,.07,0./
```

```
      DATA(FN(3,K),K=1,18)/8.8,8.6,8.1,7.4,6.6,5.8,5.0,4.2,3.4,2.65,
     11.8,1.2,.75,.4,.2,.1,.05,0./
      DATA LIM/20,14,18/
      DATA AMUL/.0794226,.6,.4062/
C FOLLOWING CONSTANTS FOR ALADDIN II CLARA & HOPE APR 1972
      DATA LIM/17/
      DATA AMUL/.10660/
      DATA(FN(1,K),K=1,17)/89.8,89.,84.,77.,68.4,59.4,50.8,
     142.,33.8,25.2,16.4,9.6,5.4,2.8,1.4,.6,0./    '
      DATA LIM/13/
      DATA AMUL/.1019/
      DATA (FN(1,K),K=1,13)/227.,224.,209.,181.,153.,125.,98.,70.
     1,42.,16.,2.,0.,0./
C ALADDIN 74 SLIT FN
      DATA LIM/30/
      DATA AMUL/.15/
      DATA (FN(1,K),K=1,30)/703.,701.,689.,671.,644.,616.,587.,558.
     1,529.,500.,472.,443.,414.,385.,356.,327.,298.,270.,241.
     2,212.,184.,155.,126.,97.,68.,41.,21.,9.,1.,0./
C POST-ALADDIN JAN 75 SLIT FN AL BURNER
      DATA AMUL/.066175,.081125/,LIM/44,36/
      DATA (FN(1,K),K=1,44)/.0949,.0948,.0945,.093,.091,.0885,.0859,.083
     14,.0809,.0784,.0758,.0733,.0708,.0682,.0657,.0632,.0606,.0581,.055
     26,.0531,.0505,.048,.0455,.0429,.0404,.0379,.0354,.0328,.0303,.0278
     3,.0252,.0227,.0202,.0176,.0151,.0126,.0101,.0075,.0050,.0027,.0013
     4,.0007,0.,0./
C POST-ALADDIN JAN 75 SLIT FN TMA RELEASE
      DATA (FN(2,K),K=1,36)/.1176,.1173,.1156,.1120,.1083,.1045,.1008,.0
     197,.0933,.0895,.0858,.082,.0783,.0745,.0708,.0670,.0633,.0596,.055
     28,.0521,.0483,.0446,.0408,.0371,.0333,.0296,.0258,.0221,.0183,.014
     36,.0108,.0071,.0034,.0005,0.,0./
C AEOLUS JAN 1975
      DATA AMUL/.15345085/,LIM/29/
      DATA (FN(1,K),K=1,29)/142.5,140.,134.,127.8,121.7,115.6,109.4,103.
     12,97.2,91.,84.8,76.6,72.5,66.3,60.2,54.2,48.1,42.0,35.8,29.4,23.2,
     217.0,11.5,6.5,4.,2.,.7,0.,0./
      DS=ABS(DLAM)/AMUL(N)+1.
      IDS=DS
      IF(IDS.GE.LIM(N)-1)GO TO 20
      DDS=IDS
      RDS=DS-DDS
      SLITFN=(1.-RDS)*FN(N,IDS)+RDS*FN(N,IDS+1)
      GO TO 30
   20 SLITFN=0.
   30 RETURN
      END
```

```
      PROGRAM MATCH(OUTPUT,TAPE5,TAPE6,TAPE2,TAPE3)
      DIMENSION NSF(8),NSTR(8),        MICRON(8),IDLIST(3),AMUL(8)
      DIMENSION AMBDAF(3)
      DIMENSION WAC(20),WAK(20)
      COMMON Y(300),X(300),YW(300),Z(801),ZW(801),T(19),DUM(801)
      INTEGER QW
      DATA ASKY/10HBLUE SKY  /
C     DATA AMUL/.397113,.397113,.324082,.324082,.324082,.340185,
C    11.62464,1.62464/
      DATA AMUL/.2712,.2712,.2712,.2712,.2712,.2712,.2712,.2712/
      DATA NSF/1,1,1,1,1,1,1,1/
C     DATA NSTR/60,60,183,278,67,231,291/
C     DATA NSTR/224,81,195,30,203,112,282,143/
C ALADDIN II CLARA AND HOPE
C     DATA NSTR/170,149,144,230,0,0,0,0./
C GOLIATH NOV 71
      DATA AMUL/.4076,.4076,0.,0.,0.,0.,0.,0./
      DATA NSTR/46,117,0,0,0,0,0,0/
      DATA MICRON/135,135,135,176,176,176,176,176/
C ALADDIN 74
      DATA NSTR/79,79,79,79,79,79,79,79/
      DATA AMUL/.3055,.3055,.3055,.3055,0.,0.,0.,0./
C POST-ALADDIN JAN 75
      DATA NSF/1,1,2,2,2,2,2,2/
      DATA NSTR/204,1,224,1,1,1,1,1/
      DATA AMUL/.2647,1.,.3245,1.,1.,1.,1.,1./
      DATA AMBDAS/4824.3/,AMBDAF/4886.3/,AMBDAP/3*4842.5/
      DATA AMUL/.3069,.3069,.3069,.3069,.3069,.3069,.3069,.3069/
      DATA NSF/1,1,1,1,1,1,1,1/
      DATA NSTR/290,143,244,143,182,143,1,1/
C WSMR OCT 77
      DATA NSTR/8*180/,AMUL/8*.3010/
      REWIND 2
      REWIND 3
      REWIND 5
C  IF NUMBA.GE.6 A CRT PLOT IS MADE, OTHERWISE A PEN PLOT
C IF NUMBA=0 NO PLOT IS MADE.
CC  IAP IS PARAMETER FOR SCALE ON APLOT.
C  IF SM=0. NO SMOOTHING IS DONE.
C  SM IS SMOOTHING PARABOLA HALF WIDTH IN ANGSTROMS.
C  IF STPL = 0. NO STRIP PLOT IS MADE.
C  STPL=1. MAKES STRIP PLOT ON OUTPUT WITH APLOT.
C    IF STPL=2. THE STRIP PLOT IS MADE BUT NO OTHER PROCESSING IS DONE.
C   IF STPL=3. ONLY STRIP PLOT IS MADE AND VALUE READ IN AS PEAK IS USED
C   FOR NSTR.
C  IF STPL=4. ONLY STRIP PLOT IS MADE, PEAK IS USED FOR NSTF
C   AND SHOT IS USED FOR SMOOTHING.
C  IF QW=QUICK PLOT, QUICK CRT PLOT OF FILES N1, N2, OF DATA TAPE IS
C  MADE BUT NO OTHER PROCESSING IS DONE.
      READ(5,210)QW,N1,N2,STPL,IAP,SM,NUMBA1,NUMBA2
  210 FORMAT(4X,I1,6X,I2,3X,I2,7X,F2.0,5X,I2,5X,F2.0,6X,I1,5X,I1)
      PRINT 211,QW,N1,N2,STPL,IAP,SM,NUMBA1,NUMBA2
  211 FORMAT(1X,3HQW=,I1,1X,5HFILES,I2,1X,2HTO,I2,7H, STPL=, F2.0,
     11X,4HIAP=,I2,5H, SM=,F2.0,6H, PEN=,I1,1X,4HCRT=,I1)
      NUMBA=NUMBA1+7*NUMBA2
      IF(QW.NE.1)GO TO 1
      CALL AL2(N1,N2,NSTR)
      GO TO 100
    1 CONTINUE
      PRINT 201
  201 FORMAT(  82H1FILE NO.  SCAN NO.  SCANS SUMMED  TEMPERATURE(DEG. K)
     1  STD DEVIATION  DESCRIPTION,9X,9HPEAK SHOT)
      XPEAK=0.
      DO 3 K=1,801
    3 ZW(K)=4800.+.25*FLOAT(K-1)
      DO 5 L=1,19
    5 T(L)=50*L+100
    7 READ (5,202)NF,NSC,NSUM,ALPH1,ALPH2,PEAK,ALPH3
      IF(EOF(5))100,8
  202 FORMAT(9X,I2,10X,I4,5X,I3,9X,A10,A9,F6.2,A5)
    8 IF(STPL.LT.1.5)CALL ZSTORE(-NSF(NF))
      CALL ISNN(NF,+1,IDUMMY)

      NSUM=MAX0(NSUM,1)
      DO 10 N=1,300
   10 Y(N)=1.
      NSTRNF=NSTR(NF
C AEOLUS MARCH 1975
      IF(NSC.GT.58)NSTRNF=NSTR(NF+2)
      IF(NSC.GT.69)NSTRNF=NSTR(NF+4)
      IF(STPL.GT.2.9)NSTRNF=PEAK
      DO 22 N=1,NSUM
      N4=300*(N+NSC)+NSTRNF   -601
      DO 20 K=1,300
```

```
      CALL ISNN(K+N4,-1,IWN3)
   20 Y(K)=Y(K)+FRAY(IWN3)
   22 CONTINUE
      IF(STPL.LE..9)GO TO 25
      ANSUM=NSUM
      DO 23 K=1,300
   23 Y(K)=Y(K)/ANSUM
      PRINT 201
      WRITE(6,201)
      PRINT 204,NF,NSC,NSUM,ALPH1,ALPH2,PEAK,ALPH3
      WRITE(6,204)NF,NSC,NSUM,ALPH1,ALPH2,PEAK,ALPH3
      IF(STPL.GE.3.9)GO TO 235
      CALL APLOT(300,IAP)
      IF(STPL.GE.1.9)GO TO 7
  235 DO 24 K=1,300
   24 Y(K)=Y(K)*ANSUM
   25 NSFNF=NSF(NF)
C
C
C
C FOR INTERACTIVE ADJUSTMENT
      INPASS=1 $ GO TO 27
C
      INPASS=0
26    NUMBA=0 $ INPASS=INPASS+1
      PRINT 1002
262   READ 1001,APUT
      IF(APUT.NE.0.)GO TO 264 $ NUMBA=10 $ GO TO 262
264   PEAK=APUT
      PRINT 1003
      READ 1001,APUT
      IF(APUT.NE.0.)AMUL(NF)=APUT
1001  FORMAT(F13.2)
1002  FORMAT(* PEAK=*)
1003  FORMAT(* AMUL=*)
27    CONTINUE
C
C
C
C
      DO 30 K=1,300
      YW(K)=AMBDAP(NSFNF) +AMUL(NF)*(PEAK-FLOAT(K))
      IF(INPASS.EQ.1)Y(K)=FRES(Y(K),YW(K))
30    CONTINUE
      IFITS=PEAK-(AMBDAF-AMBDAP(NSFNF))/AMUL(NF)
      IFITF=PEAK+(AMBDAP(NSFNF)-AMBDAS)/AMUL(NF)
      IFITS=MINO(IFITS,275)
      IFITF=MAXO(IFITF,1)
      IFITS=MAXO(IFITS,1)
      IFITF=MINO(IFITF,275)
      IF(STPL.GE.3.9)IFITS=1
      IF(STPL.GE.3.9)IFITF=300
      IF(STPL.LE.3.9)GO TO 37
      CALL APLOT(300,IAP)
      IF(STPL.GE.1.9)GO TO 7
   37 IF(ASKY.NE.ALPH1)GO TO 50
      DO 40 K=1,300
   40 X(K)=Y(K)
      XPEAK=PEAK
      PRINT 204,NF,NSC,NSUM,ALPH1,ALPH2,PEAK,ALPH3
  204 FORMAT(3X,I2,8X,I3,10X,I2,43X,A10,A9,F6.1,1X,A5)
      GO TO 7
   50 CONTINUE
      CALL FIT(801,19,IFITS,IFITF,TF,TE,FM,WAC,WAK,0.,XPEAK,AMUL(NF))
      IDLIST(1)=NF$IDLIST(2)=NSC$IDLIST(3)=NSUM
      PRINT 203,NF,NSC,NSUM,TF,TE,ALPH1,ALPH2,PEAK,ALPH3
  203 FORMAT(3X,I2,8X,I3,10X,I2,14X,F6.1,13X,F5.1,5X,A10,A9,F6.1,1X,A5)
C
C
C
C FOR INTERACTIVE ADJUSTMENT
C     IF(NUMBA.NE.10)GO TO 26
C
C
C
      IF(NUMBA.EQ.0)GO TO 7
      CALL SMOT(YW,Y,1,275,SM)
      CALL NEWPLT(IDLIST,1,3,801, 1,275,TF,TE,MICRON(NF),19,WAC,WAK,
     10,NUMBA,SM,XPEAK,AMUL(NF))
      GO TO 7
  100 CONTINUE
      IF(NUMBA.EQ.1.OR.NUMBA.EQ.2)CALL ENDPLT
      STOP
      END
```

```
C
C
C 12   FRES
C
C
      FUNCTION FRES(F,FLAMD)
      FL=FLAMD-4800.
C  USED WITH HAWAII DATA
C     FRES=F*(.930753+.0011915*FL-.00000504*FL*FL)
C
C
C  USED WITH ALADDIN AND GENIE DATA
      FRES=F*(1.+.0004903*FL)
C
      RETURN
      END
C
C
C 13   FKAY
C
C
      FUNCTION FKAY(KAYPRM)
C ALADDIN 74
      DATA A/9818.9/,B/.0004572/,T/.0011618/
C POST-ALADDIN JAN 75
      DATA A/1./,B/1.00788/,T/.0011621/
C
C
C WSMR OCT 77
      FKAY=KAYPRM
      RETURN
C
C
      FK=KAYPRM
C USED UP TO APR 73 ON ALADDIN II DATA
C     FKAY=FK/(1.-FK/950.)
C SLIGHTLY DIFFERENT NO. FOR GOLIATH NOV 71
C     FKAY=FK/(1.-FK/949.217)
C AEOLUS MARCH L975
      DATA A/2699.8/,B/.0002055/,T/.0010693/
      FKAY=FK/(1.-FK*T)-B*A
      RETURN
      END
```

```
C
C
C 14   FIT POISSON
C
C
      SUBROUTINE FIT(N,NT,N1,N2,TF,TE,FM,WACC,WAKK,SM,XPEAK,AMUL)
C
C-----------------------------------------------------------------------
C
C ZW  WAVELENGTH ARRAY SYNTHETIC SPECTRA N ELEMENTS
C  Z  AMPLITUDE  ARRAY NT BY N
C  N
C  T  TEMPERATURE ARRAY NT ELEMENTS
C  NT MUST BE LESS THAN 20
C  YW MEASURED SPECTRA WAVELENGTH ARRAY NY ELEMENTS
C  Y  MEASURED SPECTRA AMPLITUDE ARRAY  NY ELEMENTS
C  NY
C  TF BEST FIT TEMPERATURE
C  TE ERROR BARS ON TEMPERATURE
C   X = BACKGROUND ARRAY
C
C  NOTE  THE SYNTHETIC ARRAY MUST BE IN CONSTANT INCREMENTS IN WAVELENGT
C
C
C-----------------------------------------------------------------------
C
      DIMENSION WACC(20),WAKK(20),AA(20),AM(20),F(19)
      COMMON Y(300),X(300),YW(300),Z(801),ZW(801),T(19),DUM(801)
      AN=N-1
      I=N1
10     CONTINUE
      AK=AN*(YW(I)-ZW(1))/(ZW(N)-ZW(1))+1.
      IF(AK.GE.1..AND.AK.LT.AN+1.)GO TO 20
      IF(AK-1.)13,13,14
   13 N1=I+1
      GO TO 20
   14 N2=I-1
      GO TO 21
20     IF(I.GE.N2)GO TO 21
      I=I+1
      GO TO 10
   21 D=N2-N1+1
      YMAX=0. $ YMIN=1.E+08 $ BYC=0.
      DO 40 I=N1,N2
      YMAX=AMAX1(YMAX,Y(I))
      YMIN=AMIN1(YMIN,Y(I))
      IF(Y(I).LT.5.) GO TO 481
      YI1=Y(I)+1.
      BYC=BYC+(YI1-.5)*ALOG(YI1)-YI1+1./(12.*YI1)-1./(360.*YI1**3)
     1+1./(1260.*YI1**5)-1./(1680.*YI1**7)
      GO TO 485
481   KKY=1
      KY=Y(I)+.5
      IF(KY.EQ.2)KKY=2
      IF(KY.EQ.3)KKY=6
      IF(KY.EQ.4)KKY=24
      IF(KY.EQ.5)KKY=120
      YKKY=FLOAT(KKY)
      BYC=BYC+ALOG(YKKY)
485   YIP=AMAX1(.01,Y(I))
      BYC=BYC-.5*ALOG(YIP)
40    CONTINUE
      WAK=YMAX-YMIN $ WAC=YMIN
      DO 55 J=1,NT
      CALL ZSTORE(J)
      LOOP=0
44    AZ=0. $ AYZD=0. $ AYD=0. $ AYZ2D2=0. $ AYZD2=0. $ AYD2=0.
      LOOP=LOOP+1
      IF(LOOP.GT.50)F(J)=1.E+17
      IF(LOOP.GT.50)GO TO 55
      DO 46 I=N1,N2
      AK=AN*(YW(I)-ZW(1))/(ZW(N)-ZW(1))+1.
      K=AK
      CK=K
      AK=AK-CK
      ZZ=(1.-AK)*Z(K)+Z(K+1)*AK
      AZ=AZ+ZZ/D
      BA=WAK*ZZ+WAC
      B=Y(I)/(D*BA)
      BB=B/BA
      AYD=AYD+B
      AYD2=AYD2+BB
      B=B*ZZ
      AYZD=AYZD+B
```

```
      B=B/BA
      AYZD2=AYZD2+B
      B=B*ZZ
      AYZ2D2=AYZ2D2+B
46    CONTINUE
      DET=AYZ2D2*AYD2-AYZD2**2
      FNOT=AZ-AYZD $ GNOT=1.-AYD
      DELK=(GNOT*AYZD2-FNOT*AYD2)/DET
      DELC=(FNOT*AYZD2-GNOT*AYZ2D2)/DET
      WAK=WAK+DELK $ WAC=WAC+DELC
      IF(DELK.GT.1.E-10*WAK.OR.DELC.GT.1.E-10*WAC)GO TO 44
      WACC(J)=WAC
      WAKK(J)=WAK
      IF(WAC.LT.0..OR.WAK.LT.0.)F(J)=1.E+13
      IF(WAC.LT.0..OR.WAK.LT.0.)GO TO 55
      F(J)=0.
      DO 50 I=N1,N2
      AK=AN*(YW(I)-ZW(1))/(ZW(N)-ZW(1))+1.
      K=AK
      CK=K
      AK=AK-CK
      ZZ=(1.-AK)*Z(K)+AK*Z(K+1)
      XI=1.
      IF(XPEAK.LT..001)GO TO 48
      FK=XPEAK-(YW(I)-4861.34)/AMUL
      M=FK
      ACG=M
      ACG=FK-ACG
      XI=ACG*X(M+1)+(1.-ACG)*X(M)
48    B=WAK*ZZ+WAC
      B=B-Y(I)*ALOG(B)
50    F(J)=F(J)+B
55    F(J)=F(J)+BYC
201   FORMAT(1X,5E11.4)
      FM=10.E+10
      DO 60 J=1,NT
      IF(F(J).LT.FM) JT=J
      IF(F(J).LT.FM)FM=F(J)
   60 CONTINUE
      IF(JT.EQ.1.OR.JT.EQ.NT) GO TO 71
      X1=T(JT-1)
      X2=T(JT)
      X3=T(JT+1)
      DO 70 NN=1,3
      GO TO (61,62,63),NN
   61 Y1=F(JT-1)
      Y2=F(JT)
      Y3=F(JT+1)
      GO TO 64
   62 Y1=WACC(JT-1)
      Y2=WACC(JT  )
      Y3=WACC(JT+1)
      GO TO 64
   63 Y1=WAKK(JT-1)
      Y2=WAKK(JT  )
      Y3=WAKK(JT+1)
   64 Y4=(Y2-Y1)/(X2-X1)
      Y5=(Y3-Y2)/(X3-X2)
      X4=(X2*X2-X1*X1)/(X2-X1)
      X5=(X3*X3-X2*X2)/(X3-X2)
      AQ=(Y5-Y4)/(X5-X4)
      BQ=Y4-AQ*X4
      CQ=Y1-AQ*X1*X1-BQ*X1
      GO TO (65,66,67),NN
   65 TF=-BQ/(2.*AQ)
      FM=AQ*TF*TF+BQ*TF+CQ
      RM=FM*(1.+1./D)
      TE=BQ*BQ-4.*AQ*(CQ-RM)
      TE=SQRT(TE)/(2.*AQ)
      GO TO 70
   66 WAC=AQ*TF*TF+BQ*TF+CQ
      GO TO 70
   67 WAK=AQ*TF*TF+BQ*TF+CQ
   70 CONTINUE
      GO TO 72
   71 TF=T(JT)
      TE=999.0
   72 RETURN
      END
```

```
C
C
C 15    ZSTORE
C
C
      SUBROUTINE ZSTORE(L)
      COMMON Y(300),X(300),YW(300),Z(801),ZW(801),T(19),DUM(801)
      IF(L.LT.1) GO TO 16
      IF(L-LL)91,100,6
6      LM=LL+1
      DO 8 M=LM,L
8      READ(3)IV,TT,MM,KK,( Z(JJ),JJ=1,801)
      LL=L
      GO TO 100
16     N5=13267898122369
      IF(N4.NE.N5)N2=N5
      N4=N5
      NF=-L
      IF(NF.GT.N2)GO TO 22
20     REWIND 3
      N2=1
22     N3=N2+1
      IF(NF.EQ.1) GO TO 28
23     DO 25 N1=N3,NF
   24  READ(3)IV,TT,MM,KK,( Z(JJ),JJ=1,801)
      IF(EOF(3))25,24
25     CONTINUE
28     LL=0
90     N2=NF
      IF(L-1)100,6,6
   91 BACKSPACE 3
   92 LL=LL-1
      BACKSPACE 3
      IF(L.LT.LL)GO TO 92
       READ(3)IV,TT,MM,KK,( Z(JJ),JJ=1,801)
  100 CONTINUE
      RETURN
      END
C
C
C 16    SHOT RECTANGULAR
C
C
      SUBROUTINE SHOT(X,Y,N1,N2,A)
      COMMON YD(300),XD(300),YWD(300),ZD(801),ZWD(801),TD(19),Z(801)
      DIMENSION X(1),Y(1)
      IF(A.LE..001)GO TO 100
      AS=(X(N1)-X(N2))/(N1-N2)
      AS=ABS(AS)
      II=.5*A/AS+.5001
      NN=2*II-1
      II=II-1
      NN1=N1+II   $   NN2=N2-II
      DO 30 I=NN1,NN2
      Z(I)=Y(I)
      DO 30 J=1,II
      IJ=I-J   $   JI=I+J
      Z(I)=Z(I)+(Y(IJ)+Y(JI))
30     CONTINUE
      DO 40 I=NN1,NN2
40    Y(I)=Z(I)/FLOAT(NN)
100    RETURN
      END
C
C
C 17    ISNN
C
C
      SUBROUTINE ISNN(N,K,ISN)
      DIMENSION II(30)
      IF(K)20,20,10
10     N6=132876981239
      IF(N4.NE.N6) N2=N6
      N4=N6
      NF=N
      GO TO 100
20     IF(NF-N2)21,31,22
21     REWIND 2
      N5=-29
      IF(NF.EQ.1)GO TO 32
      N2=1
22     N5=-29
      N3=N2+1
      DO 30 N1=N3,NF
```

```
25       READ(2,209)(II(NN),NN=1,30)
        IF(EOF(2))30,25
30       CONTINUE
        GO TO 32
   31 IF(N.LT.N5)GO TO 50
        IF(N.GE.N5+30)GO TO 32
        GO TO 81
32       N2=NF
        N5=N5+30
        DO 40 N1=N5,N,30
        N11=N1
40       READ(2,209)(II(NN),NN=1,30)
209      FORMAT(30I3)
        N5=N11
        GO TO 81
   50 BACKSPACE 2
51       N5=N5-30
        BACKSPACE 2
        IF(N.LT.N5) GO TO 51
        READ(2,209)(II(NN),NN=1,30)
81       NN=N-N5+1
        ISN=II(NN)
100      RETURN
        END
```

```
C
C
      SUBROUTINE NEWPLT(IDLIST,K1,K2,NSYP,N1,N2,TF,TE,MICRON,NT,ACC,
     1AKK,IV,NUMBA,SM,XPEAK,AMUL)
C
C  MAKES FANCY PLOT OF SYNTHETIC SPECTRA COMBINED WITH MEASURED SPECTRA
C   IDLIST(K1) TO IDLIST(K2) IS A LIST OF SCAN NUMBERS TO BE PLOTTED
C   Z(NT,NSYP) IS AN ARRAY OF SYNTHETIC SPECTRA
C   ZW     IS THE ARRAY OF WAVELENGTHS FOR THE ELEMENTS IN Z
C   Y IS AN ARRAY OF MEASURED SPECTRA WITH NYEL ELEMENTS
C   YW     IS THE ARRAY OF WAVELENGTHS FOR THE ELEMENTS IN Y
C   TF IS THE BEST FIT TEMPERATURE FOR THAT SUM OF SCANS BY WFIT
C   TE IS THE ERROR BAR ON TF
C   MICRON IS THE SLIT WIDTHE CODE IN MICRONS
C   T    IS THE ARRAY OF TEMPERATURES USED IN THE SYNTHETIC CURVES
C   NT IS THE NUMBER OF TEMPERATURES
C   ACC AND AKK ARE THE BEST ADDITIVE AND MULTIPLICATIVE CONSTANTS
C IV SEQUENCE OF ALO USED
C
      DIMENSION IDLIST(1)
      DIMENSION ACC(20),AKK(20)
      COMMON Y(300),X(300),YW(300),Z(801),ZW(801),T(19),YP(801)
      INTEGER H
C   DRAW AXIS
      IF(NUMBA.EQ.10)GO TO 5
      CALL SUPAPL(IV,2,1,NUMBA,0,0)
      GO TO 6
    5 TID=IDLIST(3)
      CALL PPLOT(1,ZW,Z,IDLIST(1),IDLIST(2),TID)
C   FIND NUMBER OF BEST FIT TEMPERATURE
    6 TT=T(NT)
      DO 1010 N=1,NT
      DT=ABS(T   (N)-TF)
      IF(DT.LT.TT)LL=N
 1010 IF(DT.LT.TT)TT=DT
      YMAX=0.
      DO 8 M=N1,N2
8     YMAX=AMAX1(YMAX,Y(M))
C   IF NUMBA=7  A CRT PLOT WILL BE MADE.
C   IF NUMBA=10 A PRINT PLOT WILL BE MADE.
C   IF NUMBA=1  A PEN PLOT WILL BE MADE.
C   FOR PEN PLOT PF NAMED PENPLOTS MUST BE LOADED.
C   FOR CRT PLOT PF NAMED CRTPLOTS MUST BE LOADED.
C   FOR PRINT PLOT PF NAMED KITMAPAB MUST BE LOADED.
      NDI=NYEL-3
C   PLOT SYNTHETIC SPECTRA
      DO 32 I=1,NSYP
      I2=I-1
      IF(ZW(I).GT.YW(N1))GO TO 33
   32  CONTINUE
   33  DO 34 I=1,NSYP
      I1=I
      IF(ZW(I).GE.YW(N2))GO TO 35
   34  CONTINUE
   35 DO 1100 MM=1,5
      L=LL+MM-3
      IF(L.LT.1.OR.L.GT.19)GO TO 1100
      CALL ZSTORE(L)
C   SMOT CHANGES PRESENT Z ARRAY
       CALL SMOT(ZW,Z,I1,I2,SM)
      IF(MM.NE.1)GO TO 37
   37 DO 38 I=1,NSYP
      Z(I)=(Z(I)*AKK(L)+ACC(L))/YMAX
      Z(I)=AMAX1(Z(I),.01)
   38 Z(I)=4.*ALOG10(Z(I))+8.
      IF(NUMBA-10)40,39,40
   39 CALL PPLOT(MM+1,ZW,Z,1,NSYP,T(L))
      GO TO 1100
   40 IP=3
      DO 1090 M=1,NSYP
      ZZ=Z(M)
      X3=(ZW     (M)-4800.+200.*FLOAT(IV))*.08
      IF(ZZ.GT.8..OR.ZZ.LT.0..OR.X3.LT.0.)GO TO 1090
      IF(X3.GT.12.)GO TO 1096
      CALL PLOT(X3,ZZ,IP)
 1090 IP=2
 1096 AL=MM
C   LABLE SYNTHETIC SPECTRA FOR TEMPERATURE
      CALL NUMBER(12.5,AL,.2,T   (L),0.,-1)
      CALL SYMBOL(13.5,AL,.2,5HDEG K,0.,5)
 1100 CONTINUE
C   PLOT MEASURED SPECTRA
      IP=3
      DO 1069 M=N1,N2
```

```
      X2=(YW    (M)-4800.+200.*FLOAT(IV))*.08
      XM=1.
      IF(XPEAK.LT..001)GO TO 1055
      FK=XPEAK-(YW    (M)-4861.34)/AMUL
      I=FK
      ACG=I
      ACG=FK-ACG
      XM=ACG*X(I+1)+(1.-ACG)*X(I)
1055  YY=100.*Y(M)/YMAX
      YY=AMAX1(YY,1.)
      Y3=4.*ALOG10(YY)
      YP(M)=Y3
      IF(X2.LT.0..OR.Y3.LT.0..OR.Y3.GT.9.)GO TO 1069
      IF(X2.GT.12.)GO TO 1070
      IF(NUMBA.EQ.10)GO TO 1069
      CALL PLOT(X2,Y3,IP)
 1069 IP=2
 1070 IF(NUMBA.NE.10)GO TO 1071
      CALL PPLOT(7,YW,YP,N1,N2,TF)
      CALL PPLOT(8,ZW,Z,1,NSYP,TE)
      GO TO 100
C   WRITE TEMPERATURE OF MEASURED SPECTRA
 1071 CONTINUE
      CALL SYMBOL(0.,8.5,.2,31HTEMPERATURE =      +OR-     DEG K,0.,31)
      CALL NUMBER(2.8,8.5,.2,TF,0.,-1)
      CALL NUMBER(4.6,8.5,.2,TE,0.,-1)
C   WRITE SCAN NUMBERS
      YT=9.29
      XT=2.
      CALL SYMBOL(0.,9.29,.19,9HSCAN NOS.,0.,9)
      DO 1080 K=K1,K2
      FPN=IDLIST(K)
      CALL NUMBER(XT,YT,.19,FPN,0.,-1)
      XT=XT+1.
      IF(XT.LT.12.)GO TO 1080
      XT=2.
      YT=YT-.35
 1080 CONTINUE
C   LABLE SLIT SIZE
      IF(MICRON.EQ.250)CALL SYMBOL(8.,8.5,.2,20HSLIT = 2.5 ANGSTROMS,0.,
     120)
      IF(MICRON.EQ.251)CALL SYMBOL(8.,8.5,.2,20HSLIT = 3.5 ANGSTROMS,0.,
     120)
      IF(MICRON.EQ.450)CALL SYMBOL(8.,8.5,.2,20HSLIT = 4.0 ANGSTROMS,0.,
     120)
  100 RETURN
      END
C
C
C 19   PRINT PLOT
C
C
      SUBROUTINE PPLOT(KOD,X,Y,N1,N2,TITL)
      DIMENSION TITLE(70),X(1),Y(1)
      DATA HCTR/4860./,HGRD/12./,VCTR/4./,VGRD/1.7143/,FST/0./
      DATA TITLE/6HWAVELN,6H (ANG),6HAMPLIT,3HUDE,-1.,0.,8H    FILE,
     +8H    SCAN,8H  SUMMED,0.,0.,0.,8HTEMPERAT,3HURE,0.,0.,
     +8H(K) +OR-,0.,0.,0.,1HE,0.,0.,1HD,0.,0.,1HC,0.,0.,1HR,
     +0.,0.,1HA/
      IF(FST.NE.0.)GO TO 11
      DO 10 J=35,70
   10 TITLE(J)=0.
      DO 101 J=50,62,3
  101 TITLE(J)=-1.
      DO 102 J=40,42
  102 TITLE(J)=-1.
      TITLE(48)=TITLE(46)=1.
      TITLE(64)=999.
      TITLE(34)=3HXXX
   11 FST=1.
      KOM=3
      IF(KOD.EQ.1)KOM=0
      IF(KOD.EQ.8)KOM=4
      TITLE(65)=KOD-1
      IF(KOD.EQ.7)TITLE(65)=29.
      IF(KOD.NE.1)GO TO 12
      TITLE(10)=N1 $ TITLE(11)=N2 $ TITLE(12)=TITL
   12 CONTINUE
      IF(KOD.EQ.7)TITLE(16)=TITL
      IF(KOD.EQ.8)TITLE(18)=TITL
      IF(KOD.GE.2.AND.KOD.LE.6)TITLE(-3*KOD+38)=TITL
      CALL MAPA(X,Y,N1,N2,KOM,HCTR,HGRD,VCTR,VGRD,TITLE)
      RETURN
      END
```

```
C
      SUBROUTINE SUPAPL(IV,TYPE,IAXIS,NUMBA,IDIM,ID)
C
C  MAKES VARIOUS FORMS OF PLOTS FOR ALO TEMPERATURE PROBLEMS
C       IV=0,1 FOR DELTA V = 0 OR DELTA V = 1
C TYPE=0,2,5,FOR A LINEAR,2 CYCLE LOG,OR SQUARE ROOT PLOTS,RESPECTIVELY
C       IAXIS=0,1 FOR NO NEW AXIS OR NEW AXIS
C       NUMBA=NO. OF PLOTS TO BE MADE(NOT NO OF AXIS)
C NUMBA 5 OR LESS IS PEN AND INK    PLOT, 6 OR GREATER IS        CRT PL
C       IDIM=DIMENSION OF INPUT ARRAY,YARRAY, FROM LEFT TO RIGHT
C IF IDIM=0 NO CURVE IS PLOTTED
C       YARRAY=ARRAY TO BE PLOTED
C ID= IDENTIFICATION NUMBER TO BE PRINTED WITH AXIS(4 DIGITS)
C IF ID=0 NO NUMBER IS PRINTED AT ALL
C
      INTEGER TYPE
      DIMENSION YARRAY(1)
      DIMENSION PRID(3)
      PRID(1)=10HKITROSSER
      PRID(2)=DATE(DDUM)
      PRID(3)=TIME(TDUM)
      IF(MSTART.NE.3624321061.AND.NUMBA.LE.5)CALL PLTID3(PRID,340.,11.,
     11.)
      IF(MSTART.NE.3624321061.AND.NUMBA.LE.5)CALL NEWPEN(3)
      IF(MSTART.NE.3624321061.AND.NUMBA.GE.6)CALL CRTPLT(PRID,1.,17.)
      IF(MSTART.NE.3624321061)MEND=0
      IF(MSTART.NE.3624321061)CALL PLOT(1.,1.,-3)
      MSTART=3624321061
      MEND=MEND+1
      IF(IAXIS.EQ.0)GO TO 400
C     AXIS
      IF(MEND.NE.1.AND.NUMBA.GE.6)CALL FRAME(1.5,1.5)
      IF(MEND.NE.1.AND.NUMBA.LE.5)CALL PLOT(17.,0.,-3)
C     THE FOUR BORDER AXIS
      CALL PLOT(0.,0.,3)
      CALL PLOT(12.,0.,2)
      CALL PLOT(12.,8.,2)
      CALL PLOT(0.,8.,2)
      CALL PLOT(0.,0.,2)
C     X AXIS FEDUCIARIES
      DO 120 K=1,2
      DO 120 I=1,149
      A=.05
      IF(I.EQ.5*(I/5))A=.1
      IF(I.EQ.10*(I/10))A=.15
      B=I
      B=.08*B
      C=0.
      IF(K.EQ.2)A=8.-A
      IF(K.EQ.2)C=8.
      CALL PLOT(B,A,3)
      CALL PLOT(B,C,2)
  120 CONTINUE
C     LABLE X AXIS
      IA=4800-200*IV
      IB=IA+150
      DO 303 M=IA,IB,10
      X=M-IA
      IF(M.EQ.50*(M/50))GO TO 301
      FPN=M 100*(M/100)
      X=.08*X-.11
      CALL NUMBER(X,-.35,.15,FPN,0.,-1)
      GO TO 302
  301 FPN M
      X=.08*X-.35
      CALL NUMBER(X,-.4,.2,FPN,0.,-1)
  302 CONTINUE
  303 CONTINUE
      CALL SYMBOL(3.8,-.8,.2,22HWAVELENGTH (ANGSTROMS),0.,22)
      CALL SYMBOL(6.2,-.6,.2,1H.,0.,1)
      CALL SYMBOL(7.4,-.8,.2,1H/,0.,1)
      CALL PLOT(3.87,-1.25,3)
      CALL PLOT(4.07,-1.25,2)
      CALL PLOT(3.97,-1.07,2)
      CALL PLOT(3.87,-1.25,2)
      CALL SYMBOL(4.12,-1.25,.25,14HV=  SEQUENCE A,0.,14)
      CALL SYMBOL(7.62,-1.25,.15,1HL,0.,1)
      CALL SYMBOL(7.77,-1.25,.25,1HO,0.,1)
      FPN=IV
      CALL NUMBER(4.62,-1.25,.25,FPN,0.,-1)
C     LABLE Y AXIS
      IF(ID)1004,1004,1005
 1004 CONTINUE
      CALL SYMBOL(-1.1,2.3,.2,26HRELATIVE INTENSITY        ,90.,26)
```

```
      GO TO 1006
 1005 CONTINUE
      FIDNO=ID
      CALL SYMBOL(-1.1,1.1,.2,26HRELATIVE INTENSITY  NUMBER,90.,26)
      CALL NUMBER(-1.1,6.5,.2,FIDNO,90.,-1)
 1006 CONTINUE
C     LINEAR Y AXIS FEDUCIARIES
      IF(TYPE-2)1020,200,1021
 1020 DO 180 K=1,2
      DO 180 I=1,99
      A=.05
      IF(I.EQ.5*(I/5))A=.1
      IF(I.EQ.10*(I/10))A=.15
      B=I
      B=.08*B
      C=0.
      IF(K.EQ.2)A=12.-A
      IF(K.EQ.2)C=12.
      CALL PLOT(A,B,3)
      CALL PLOT(C,B,2)
  180 CONTINUE
C     LABLE Y AXIS LINEARLY
      CALL NUMBER(-.25,-.1,.2,0.,0.,-1)
      DO 340 M=10,90,10
      Y=M
      YY=.08*Y-.1
      CALL NUMBER(-.45,YY,.2,Y,0.,-1)
  340 CONTINUE
      CALL NUMBER(-.65,7.9,.2,100.,0.,-1)
      GO TO 270
C     LOGARITHMIC Y AXIS FEDUCIARIES
  200 DO 260 J=1,2
      DO 260 K=1,2
      DO 210  MA=1,4
      DO 210 M=1,4
      AMA=MA-1
      A=M
      A=4.*ALOG10(.1*A+1.+.5*AMA)
      FK=K
      A=A+4.*FK-4.
      FJ=J
      B=11.95*FJ-11.95
      C=B+.05
      CALL PLOT(B,A,3)
      CALL PLOT(C,A,2)
  210 CONTINUE
      DO 220 MA=3,6
      DO 220 M=2,8,2
      A=M
      AMA=MA
      A=4.*ALOG10(.1*A+AMA)
      FK=K
      A=A+4.*FK-4.
      FJ=J
      B=11.90*FJ-11.90
      C=B+.1
      CALL PLOT(B,A,3)
      CALL PLOT(C,A,2)
  220 CONTINUE
      DO 230 M=1,8
      A=M
      A=4.*ALOG10(A+1.)
      FK=K
      A=A+4.*FK-4.
      FJ=J
      B=11.80*FJ-11.80
      C=B+.2
      CALL PLOT(B,A,3)
      CALL PLOT(C,A,2)
  230 CONTINUE
      DO 240 M=1,2
      A=M
      A=4.*ALOG10(A+.5)
      FK=K
      A=A+4.*FK-4.
      FJ=J
      B=11.85*FJ-11.85
      C=B+.15
      CALL PLOT(B,A,3)
      CALL PLOT(C,A,2)
  240 CONTINUE
      DO 250 M=1,3
      A=M
      A=4.*ALOG10(A+6.5)
```

```
      FK=K
      A=A+4.*FK-4.
      FJ=J
      B=11.85*FJ-11.85
      C=B+.15
      CALL PLOT(B,A,3)
      CALL PLOT(C,A,2)
  250 CONTINUE
      A=4.
      FJ=J
      B=11.75*FJ-11.75
      C=B+.25
      CALL PLOT(B,A,3)
      CALL PLOT(C,A,2)
  260 CONTINUE
C     LABLE Y AXIS LOGARYTHMICALLY
      DO 310 M=1,9
      FFN=M
      Y=4.*ALOG10(FFN)-.08
      CALL NUMBER(-.2,Y,.15,FFN,0.,-1)
  310 CONTINUE
      DO 320 M=10,90,10
      FFN=M
      Y=4.*ALOG10(FFN)-.08
      CALL NUMBER(-.35,Y,.15,FFN,0.,-1)
  320 CONTINUE
      CALL NUMBER(-.5,7.93,.15,100.,0.,-1)
      GO TO 270
 1021 CONTINUE
C LABLE Y AXIS FOR SQUARE ROOT
      CALL NUMBER(-.2,-.08,.15,0.,0.,-1)
      DO 1022 M=10,90,10
      FFN=M
      Y=.8*SQRT(FFN)-.08
      CALL NUMBER(-.35,Y,.15,FFN,0.,-1)
 1022 CONTINUE
      CALL NUMBER(-.5,7.92,.15,100.,0.,-1)
C SQUARE ROOT FEDUCIARIES
      DO 1028 K=1,2
      DO 1028 I=1,99
      A=.05
      IF(MOD(I,5).EQ.0)A=.1
      IF(MOD(I,10).EQ.0)A=.15
      B=I
      B=.8*SQRT(B)
      C=0.
      IF(K.EQ.2)A=12.-A
      IF(K.EQ.2)C=12.
      CALL PLOT(A,B,3)
      CALL PLOT(C,B,2)
 1028 CONTINUE
  270 CONTINUE
  400 CONTINUE
      IF(IDIM.EQ.0)GO TO 407
C     PLOT
      IT=3
      YMAX=0.
      DO 401 I=1,IDIM
      IF(YARRAY(I).GT.YMAX)YMAX=YARRAY(I)
  401 CONTINUE
      DO 405 I=1,IDIM
      X=I-1
      DIM=IDIM-1
      X=X*(12./DIM)
      IF(ITYPE-2)402,403,406
  402 Y=YARRAY(I)*(8./YMAX)
      GO TO 404
  403 IF(YARRAY(I).LT.YMAX/100.)YARRAY(I)=YMAX/100.
      Y=4.*ALOG10(100.*(YARRAY(I)/YMAX))
      GO TO 404
  406 IF(YARRAY(I).LT.0.)YARRAY(I)=0.
      Y=8.*SQRT(YARRAY(I)/YMAX)
  404 IF(Y.LT.0.)Y=0.
      CALL PLOT(X,Y,IT)
       IT=2
  405 CONTINUE
  407 RETURN
      END
```

```
C 21   APLOT
C
C
      SUBROUTINE APLOT(NE,ND)
      DIMENSION IFO(3),B(121)
      COMMON Y(300),X(300),YW(300),Z(801),ZW(801),T(19),DUM(801)
      DATA IFO/10H(1X,I3,1X,,10HF5.2,1X,12,10H1A1        )/
C  NE=NUMBER OF ELEMENTS IN ARRAY TO BE PLOTTED.
C  Y=ARRAY TO BE PLOTTED.
C  ND=NUMBER OF DECADES FOR LOG PLOT.
C  ND=0 MAKES LINEAR PLOT.
C  ND=NEGATIVE GIVES THAT FRACTION OF A DECADE.
C  CALL APLOT(-1,DUMMY,NSIZE) TO SET WIDTH OF PLOT.
C  DEFAULT VALUE IS 120 SPACES.
C  MAXIMUM WIDTH IS 120 SPACES.
      DATA A0/1H /,A1/1H./
      NSIZE=120
      SIZE=NSIZE
      YM=0.
      DO 10 N=1,NE
10     YM=AMAX1(YM,Y(N))
      IF(ND.NE.0)F=NSIZE/ND
      IF(ND.LT.0)F=-NSIZE*ND
      DO 40 N=1,NE
      YN=Y(N)/YM
      IF(ND.EQ.0)GO TO 21
      YN=AMAX1(YN,.000000001)
      NY=ALOG10(YN)*F+SIZE+1.000001
      GO TO 22
21     NY=SIZE*YN+1.000001
22     NY=MAX0(1,NY)
      NY=MIN0(NSIZE+1,NY)
      NSIZE1=NSIZE+1
      DO 30 J=1,NSIZE1
30     B(J)=A0
      B(NY)=A1
      YN=ABS(Y(N))
      YN=AMAX1(YN,.000000000001)
      IAL=ALOG10(YN)+1.0000000001
      IAL=31-IAL
      IAL=MIN0(31,IAL)
      IF(IAL.LE.26)GO TO 37
      CALL MXPUTX(IAL,IFO(2),4)
      WRITE(6,IFO)N,Y(N),(B(J),J=1,NY)
      GO TO 40
37     NYN=Y(N)
      WRITE(6,292)N,NYN,(B(J),J=1,NY)
292    FORMAT(1X,I3,1X,I5,1X,121A1)
40     CONTINUE
      CONTINUE
      CONTINUE
      CONTINUE
      CONTINUE
      CONTINUE
      RETURN
      END
C
C
C 22   AL2
C
C
      SUBROUTINE AL2(N1,N2,NSTR)
      DIMENSION NSTR(8)
      COMMON Y(300),X(300),YW(300),Z(801),ZW(801),T(19),DUM(801)
      WRITE(6,201)
201    FORMAT(1X,13HENTER PROGRAM)
      NUM=1
      DO 110 NN=N1,N2
      CALL ISNN(NN,+1,IDUMMY)
      DO 100 N=1, 149
      I=300*N+NSTR(NN)-301
      ISNMAX=0
      DO 20 K=1,300
      II=I+K
      CALL ISNN(II,-1 ISN)
      IF(ISNMAX.LT.ISN)ISNMAX=ISN
   20 Y(K)=ISN
      IF(ISNMAX.LE.0)GO TO 105
      CALL SMOOTH(  300,11)
      NID=1000*NN+N
      CALL OWPL(  NUM,NID,300)
  100 CONTINUE
  105 CONTINUE
      PRINT 203,NN,N,NUM
```

```
203     FORMAT(1X,3I6)
  110 CONTINUE
      CALL ENDPLT
      RETURN
      END
C
C
C 23    SMOOTH
C
C
      SUBROUTINE SMOOTH(   NDIM,NSM)
      COMMON Y(300),X(300),YW(300),Z(801),ZW(801),T(19),S(801)
      IF(NSM.LE.1) GO TO 100
      N=NSM/2
      FNSM=N*2+1
      DO 10 K=1,N
      K2=N+K+1
      K3=NDIM+K-N
      S(K+1)=Y(K3)
   10 S(K2)=Y(K)
      DO 60 I=1,NDIM
      DO 20 K=1,N
   20 S(K)=S(K+1)
      S(N+1)=Y(I)
      Y(I)=0.
      DO 30 K=1,N
      IF(I+K.GE.NDIM+1) GO TO 40
   30 Y(I)=Y(I)+Y(I+K)
   40 N1=N+I-NDIM+1
      N1=MAX0(N1,1)
      N1=N+N1
      DO 50 K=1,N1
   50 Y(I)=Y(I)+S(K)
   60 Y(I)=Y(I)/FNSM
  100 RETURN
      END
C
C
C 24    QWPL
C
C
      SUBROUTINE QWPL(         NO,ID, ZE)
C     Y ARRAY IN
C   NO OF PLOTS OUTPUTTED EXCEPT MAK  NO=1 AT FIRST ENTRY
C   ID OF PLOT IN
C   IZE OF Y  ARRAY
      DIMENSION PROGID(3)
      COMMON Y(300),X(300),YW(300),Z(801),ZW(801),T(19),DUM(801)
      PROGID(1)=10HKITROSSER
      PROGID(2)=DATE(DDUM)
      PROGID(3)=TIME(TDUM)
      IF(NO.EQ.1)CALL CRTPLT(PROGID,1.,17.)
      IF(NO.EQ.1)CALL PLOT(3.65,0.,-3)
      IF(NO.EQ.1)GO TO 61
      IF(NO (NO/4)*4.EQ.1)CALL FRAME(4.15,.5)
      IF(NO-(NO/4)*4.EQ.1)GO TO 61
      CALL PLOT(4.25,0.,-3)
   61 FID=ID
      CALL PLOT(-4.,.4,3)
      CALL PLOT(0.,.4,2)
      CALL PLOT(0.,10.4,2)
      YMAX=0.
      DO 1 I=1,IZE
      IF(Y       (I).GT.YMAX)YMAX=Y       (I)
1       CONTINUE
      IF(YMAX.LE.0.)GO TO 3
      CALL NUMBER(-2.,-.4,.2,FID,0.,-1)
      CALL SYMBOL(-3.,0.,.2,5HYMAX=,0.,5)
      CALL NUMBER(-2.,0.,.2,YMAX,0.,-1)
      IT=3
      DO 2 I=1,IZE
      YY=-4.*Y       (I)/YMAX
      IF(YY.GT.0.)YY=0.
      FI=I-1
      FIZ=IZE-1
      XX=.4+10.*FI/FIZ
      CALL PLOT(YY,XX,IT)
      IT=2
2       CONTINUE
      DO NOTHING
3       CONTINUE
      RETURN
      END
```

```
C
C 26   SLIT PROGRAM
C
C
      PROGRAM SLIT(INPUT,OUTPUT,TAPE2,TAPE6=OUTPUT,TAPE7)
      DIMENSION X(100),Z(100),V(10),D(10),G(10),DA(3)
      PRINT 909
909    FORMAT(/*  *****REMEMBER TO COPY TAPE7 AFTER EXECUTI*
     + *ON.*****  */)
      REWIND 2
      READ(2,902)AAN
      N=AAN+.000001
902    FORMAT(F9.3)
      DO 5 I=1,N
5      X(I)=I
      READ(2,902)(Z(I),I=1,N)
      WRITE(6,904)
904    FORMAT(//3X*X*5X*Z*/)
      WRITE(6,903)(X(I),Z(I),I=1,N)
903    FORMAT(1X,F3.0,1X,F5.0)
C   V(1)=T   V(2)=C   V(3)=W   V(4)=A
      V(2)=.5*(Z(1)+Z(N))
      V(4)=0.
      DO 10 I=1,N
      IF(Z(I).GT.V(4))JX=I
      IF(Z(I).GT.V(4))V(4)=Z(I)
10    CONTINUE
      V(4)=V(4)-V(2)
      V(1)=X(JX)
      ZW=V(2)+.5*V(4)
      DO 15 I=1,N
      JX1=I
      IF(ZW.LT.Z(I))GO TO 16
15    CONTINUE
16    DO 17 I=JX1,N
      JX2=I
      IF(ZW.GT.Z(I))GO TO 18
17    CONTINUE
18    V(3)=X(JX2)-X(JX1)
      D(3)=V(3) $ D(1)=V(1) $ D(2)=D(4)=V(4)
      KK=0
      WRITE(6,905)
905    FORMAT(/5X*N*5X*I*11X*C*11X*W*11X*A*/)
      DATA DA/10HVALUE     ,10HRANGE     ,10HFIT CRITER/
      WRITE(6,906)KK,N,(V(K),K=1,4),DA(1)
      WRITE(6,906)KK,N,(V(K),K=1,4),DA(2)
      WRITE(6,907)
      DO 30 KK=1,40
      DO 20 K=1,4
      CALL FCRIT(N,X,Z,K,V,D(K),G(K))
20     CONTINUE
      REWIND 7
      WRITE(7,908)AAN,(V(K),K=1,4),(X(I),Z(I),I=1,N)
      WRITE(6,906)KK,N,(V(K),K=1,4),DA(1)
      WRITE(6,906)KK,N,(D(K),K=1,4),DA(2)
      WRITE(6,906)KK,N,(G(K),K=1,4),DA(3)
      WRITE(6,907)
906    FORMAT(2(1X,I2),4G12.6,1X,A10)
907    FORMAT(1X)
30     CONTINUE
908    FORMAT(5F10.4)
      STOP
      END
      SUBROUTINE FCRIT(N,X,Z,K,V,DG,GM)
      DIMENSION X(1),Z(1),V(1)
      G0=V(K)  $  DG=ABS(DG)  $  GM=0.
      IF(K.EQ.2.OR.K.EQ.4)GM=1.E+08
      DO 10 I=1,20
      F=I-1
      G=G0-DG+F*DG/10.
      V(K)=G
      IF(K.EQ.2.OR.K.EQ.4)GO TO 5
      GH=FCN(N,X,Z,V)
      IF(GH.GT.GM)G1=V(K)
      IF(GH.GT.GM)GM=GH
      GO TO 10
5      GH=FSQ(N,X,Z,V)
      IF(GH.LT.GM)G1=V(K)
      IF(GH.LT.GM)GM=GH
10     CONTINUE
      V(K)=G1
      DG=.4*DG+ABS(G1-G0)
      RETURN
      END
```

```
      FUNCTION FCN(N,X,Z,V)
      DIMENSION X(1),Z(1),V(1)
      T=V(1)  $  C=V(2)  $  W=V(3)  $  A=V(4)  $  RN=N  $  ZA=0.
      DO 10 I=1,N
10     ZA=ZA+Z(I)-C
      ZA=ZA/RN
      YA=0.
      DO 12 I=1,N
      XT=X(I)-T
      YA=YA+YN(XT,A,W)
12     CONTINUE
      YA=YA/RN
      YS=0.
      DO 14 I=1,N
      XT=X(I)-T
      YI=YN(XT,A,W)-YA
      YS=YS+YI*YI
14     CONTINUE
      YS=YS/RN
      YNM=0.  $  ZS=0.
      DO 20 I=1,N
      XT=X(I)-T
      YNM=YNM+(Z(I)-C-ZA)*(YN(XT,A,W)-YA)
      ZS=ZS+(Z(I)-C-ZA)**2
20     CONTINUE
      YNM=YNM/RN  $  ZS=ZS/RN
      FD=ZS*YS
      FCN=YNM/SQRT(FD)
40     RETURN
      END
      FUNCTION FSQ(N,X,Z,V)
      DIMENSION X(1),Z(1),V(1)
      T=V(1)  $  C=V(2)  $  W=V(3)  $  A=V(4)  $  RN=N  $  FSQ=0.
      DO 10 I=1,N
      XT=X(I)-T
      FI=Z(I)-C-YN(XT,A,W)
10     FSQ=FSQ+FI*FI
      FSQ=FSQ/RN
      RETURN
      END
      FUNCTION YN(X,A,W)
      IF(X.LT.-W)GO TO 10
      IF(X.GT.+W)GO TO 10
      AX=X
      IF(X.GT.0.)AX=-X
      YN=A*(AX+W)/W
      GO TO 20
10     YN=0.
20     RETURN
      END
C
C
C 22   SLTIC PROGRAM
C
C
      PROGRAM SLTIC(INPUT,OUTPUT,TAPE2,TAPE6,TAPE7=OUTPUT)
      DIMENSION X(200),Z(200),TITLE(70)
      REWIND 6
      REWIND 2
      XMAX=0.
      ZMAX=0.
      ZMIN=1.E+10
      DO 15 J=1,10
      READ(2,901)AAN,T,C,W,A
      IF(EOF(2))20,10
901    FORMAT(5F10.4)
10     N=AAN+.00001
      DATA L3/0/
      L1=L3+1
      L2=L1+N-1
      L3=L2
      READ(2,901)(X(I),Z(I),I=L1,L2)
      DO 12 I=L1,L2
      X(I)=ABS(X(I)-T)
      Z(I)=(Z(I)-C)/(A*W)
      IF(X(I).GT.XMAX)XMAX=X(I)
      IF(Z(I).GT.ZMAX)ZMAX=Z(I)
      IF(Z(I).LT.ZMIN)ZMIN=Z(I)
      WRITE(7,902)X(I),Z(I)
12     CONTINUE
902    FORMAT(2F10.3)
15     CONTINUE
20     CONTINUE
      AM=ALOG10(.2*XMAX)
```

```
      M=AM
      IF(AM.LT.0.)M=-INT(1.-AM)
      IH=.2*XMAX/10.**M-.0000000001
      HGRD=2.
      IF(IH.GT.2)HGRD=4.
      IF(IH.GT.4)HGRD=10.
      HGRD=HGRD*10.**M
      HCTR=HGRD*2.5
      AM=ALOG10(2.*ZMAX/9.)
      M=AM
      IF(AM.LT.0.)M=-INT(1.-AM)
      IH=(2.*ZMAX/9.)/10.**M-.00000001
      VGRD=2.
      IF(IH.GT.2)VGRD=4.
      IF(IH.GT.4)VGRD=10.
      VGRD=VGRD*10.**M
      VCTR=VGRD*2.
      DO 30 J=1,70
30     TITLE(J)=0.
      TITLE(1)=6HWAVELN    $    TITLE(2)=6H STEPS
      TITLE(3)=6HAMPLIT    $    TITLE(4)=6HUDE
      TITLE(5)=-1.
      TITLE(64)=999.    $    TITLE(65)=29.
      TITLE(7)=3HXXX
      DO 40 J=1,3
      IF(J.EQ.1)KOM=0
      IF(J.EQ.2)KOM=3
      IF(J.EQ.3)KOM=4
      CALL MAPA(X,Z,L,L3,KOM,HCTR,HGRD,VCTR,VGRD,TITLE)
40     CONTINUE
      CONTINUE
      CONTINUE
      CONTINUE
      CONTINUE
      STOP
      END
```

```
C
C
C 36 LIGHTBOX AVERAGE PROGRAM
C
C
      PROGRAM AVG(TAPE2,OUTPUT,INPUT)
      REWIND 2
      PRINT 104
      READ 102,FF
      IF=FF
      CALL ISNN(IF,+1,IDUMMY)
      DO 30 I=1,100
      PRINT 101
      READ 102,FS
      PRINT 103
      READ 102,FL
      IS=FS $ IL=FL
      ISUM=0
      DO 20 N=IS,IL
      CALL ISNN(N,-1,IW)
      ISUM=ISUM+IW
20    CONTINUE
      FSUM=ISUM
      FSUM=FSUM/FLOAT(IL-IS+1)
      PRINT 105,FSUM
30    CONTINUE
101   FORMAT(1X,*NO. OF FIRST WD.-*)
102   FORMAT(F12.3)
103   FORMAT(1X,*NO. OF LAST  WD.-*)
104   FORMAT(1X,*FILE NO. *)
105   FORMAT(1X,*AVERAGE = *,F8.2)
      STOP
      END
C
C
C 17   ISNN
C
C
      SUBROUTINE ISNN(N,K,ISN)
      DIMENSION II(30)
      IF(K)20,20,10
10     N6=1320762081239
      IF(N4.NE.N6) N2=N6
      N4=N6
      NE=N
      GO TO 100
20     IF(NE-N)21,31,22
21     REWIND 2
      N5=-29
      IF(NE.EQ.1)GO TO 32
      N2=1
22     N5=-29
      N3=N2+1
      DO 30 NE=2,N3,NE
25     READ(2,209)(II(NN),NN=1,30)
      IF(EOF(2))30,25
30     CONTINUE
      GO TO 32
   31 IF(N.LT.N5)GO TO 50
      IF(N.GE.N5+30)GO TO 32
      GO TO 81
32     N2=NE
      N5=N5+30
      DO 40 NE=N2,N,30
      [illegible]
40     READ(2,209)(II(NN),NN=1,30)
209    FORMAT(30I3)
      NE=N+1
      GO TO 81
   50 BACKSPACE 2
51     N5=N5-30
      BACKSPACE 2
      IF(N.LT.N5) GO TO 51
      READ(2,209)(II(NN),NN=1,30)
81     NN=N-N5+1
      ISN=II(NN)
100    RETURN
      END
```